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INFLUENCE OF pH AND TEMPERATURE ON THE SURVIVAL OF COLIFORMS AND ENTERIC PATHOGENS WHEN EXPOSED TO FREE CHLORINE[1]

By C. T. BUTTERFIELD, *Principal Bacteriologist*, ELSIE WATTIE, *Bacteriologist*, STEPHEN MEGREGIAN, *Assistant Chemist*, and C. W. CHAMBERS, *Junior Bacteriologist, United States Public Health Service*

Studies of water disinfection methods, with particular reference to the requirements in military and war industry areas, have been instituted at the Stream Pollution Investigations Laboratory of the United States Public Health Service at Cincinnati, Ohio. Streeter (*1*) has outlined these studies of water disinfection methods. In connection with these studies, Moore (*2*) has shown the use of p-aminodimethylaniline as an indicator for "free chlorine"; Wattie and Chambers (*3*) have reported on the relative resistance of coliforms and some of the enteric pathogens to the excess-lime method of water treatment; and Moore, Megregian, and Ruchhoft (*4*) have presented data on some of the chemical aspects of the ammonia-chlorine treatment of water.

Streeter (*1*) on the basis of preliminary results on chlorination has pointed out the desirability of (*a*) "maintaining free chlorine residuals of 0.1 to 0.2 p. p. m., where rapid and effective bactericidal action is needed," and (*b*) "chlorinating waters of any free ammonia content beyond the break-point whenever the high bactericidal power of free chlorine is required."

A brief survey of the related literature indicates that little information is available concerning the bactericidal properties of "free" chlorine to the absolute exclusion of chlorine-addition products (chloramines, etc.). It is well known that the bacterial death rate with chlorine-addition products is markedly less than that of free chlorine, though such products are included with the free chlorine in the ordinary tests for residuals. This points to the necessity of the elimination of all chlorine-absorbing, or chlorine-addition products, from the suspending menstruum in determinations of the bactericidal properties of free chlorine.

[1] From the Division of Public Health Methods, National Institute of Health, Stream Pollution Investigations, Cincinnati, Ohio.

Tonney, Greer, and Danforth (*5*) studied the minimal "chlorine death points" of vegetative cells of a number of genera of bacteria. They used sterile distilled water as a suspending menstruum and discarded the results of any tests in which definite chlorine losses were observed. While the pH of their initial waters was stated to be 6.4 to 7.2, apparently no effort was made to control the hydrogen-ion concentration of the final mixtures. Tests were made at various temperatures, from room temperature to near the freezing point. They concluded, in general, that the vegetative cells of the enteric pathogens studied were killed by a 15-second exposure to 0.1 p. p. m. of free chlorine while coliforms, on the whole, were more resistant; nine strains of coli required 0.25 p. p. m. of free chlorine for complete destruction in 15 seconds. This work was repeated by Tonney, Greer, and Liebig (*6*), confirming these results with an increased number of genera and species. In this later study more thorough procedures were used to assure the elimination of chlorine absorption products but apparently the pH was not controlled.

Heathman, Pierce, and Kabler (*7*) studied the resistance of coliforms and *E. typhosa* to chlorine and chloramines. They used tap water as a suspending medium with a pH range of from 6.4 to 7.9, with observations at two temperature ranges, room temperature and slightly above freezing. In their tests of the bactericidal effect of free chlorine they attempted to destroy the chlorine absorption substances by preliminary doses of chlorine. They concluded in part that (1) the disinfection action of chlorine is variable within limits, (2) longer times are required to kill coliforms and *E. typhosa* at lower temperatures, (3) recently isolated strains are more resistant to chlorine, and (4) there is a possibility, according to their observations, that *E. typhosa* may persist in chlorine-treated waters longer than the coliforms. Subsequent studies and our own experiences lead to the belief that the methods used in obtaining chlorine-demand-free water were not successful in all cases, and that their results cannot be accepted as indicative of the effect of either free chlorine or chloramine alone. This belief is substantiated by the statement of Heathman et al. that "chlorine in the low-initial-residual ranges exhibited a killing action very similar to chloramine," and that "with greater initial residuals about one-half of the waters studied also resembled chloramine in action." Residual chlorine and chloramine were determined by orthotolidine. Thus, considerable doubt may exist as to the nature of the bactericidal agents active in their studies. There is general agreement among workers in this field that at normal temperatures and pH ranges the killing action of chlorine is much more rapid than that of chloramine.

As this cursory review of the literature dealing with the bacterial

killing power of "free" chlorine and the results of preliminary observations reported by Streeter (*1*) indicated quite clearly the need for further intensive study of this problem, particularly of the bactericidal action of free chlorine and some of the factors which may affect its efficiency, studies were made of the bactericidal properties of free chlorine as affected by the following variables: (1) time of exposure to chlorine, (2) variations in the hydrogen-ion concentration of the suspending water, (3) the temperature of the water, and (4) to a limited extent only, the individual variations in resistance to chlorine, under the above conditions, of some of the coliforms and enteric pathogens. The results obtained should be of especial interest whenever free chlorine, apart from chlorine-addition products, is used as the bactericidal agent as, for instance, post break-point chlorine in the break-point chlorination process.

METHODS

Chlorine-free, chlorine-demand-free water.—The primary requirement for such a study was a water of the necessary properties for use as the basic suspending menstruum in all tests. These properties might be described as follows. The water must be: (1) nontoxic to bacteria except for the effect of the variables under test, such as chlorine and pH; (2) well buffered at the required pH; (3) free of all ammonia and organic matter capable of combining with chlorine to form chlorine-addition products; (4) free of chlorine and of substances which would give a test with the usual chlorine reagents, and (5) of such a nature that when a calculated amount of chlorine or hypochlorite solution is applied to a definite volume of the water it may be recovered quantitatively after 5 minutes without a loss in residual, and after several hours contact must still give a test for free chlorine.

The preparation of a water to meet the above requirements offered considerable difficulties. A detailed consideration of the procedures to be observed in the preparation of such waters has been presented by Megregian (*8*). In brief, the waters used in this study were prepared as follows: Carboys containing approximately 5 gallons of a good quality distilled water were dosed with 3 to 5 p. p. m. of chlorine and a chlorine residual was maintained for several days. About 36 hours prior to each test, 5 liters of this water were drawn off to a 6-liter Erlenmeyer flask, Clarks and Lubs (*9*) buffer solutions of the desired hydrogen-ion concentration were added at a ratio of 50 ml. of buffer per liter of water, and the buffered water was brought to a boil and allowed to simmer for 1 minute. After cooling (usually overnight) the water was tested for residual chlorine and dechlorinated with a freshly prepared 0.2-percent solution of sodium sulfite in such a manner that at most only a very slight trace of sulfite remained. The

water was then vigorously shaken, allowed to stand for a few hours in order to oxidize any trace of excess sulfite with dissolved oxygen, and then boiled for 20 minutes to kill vegetative cells introduced during the adjustment. Water thus prepared was cooled to the desired temperature for each test. It was not held longer than 18 to 24 hours before use, as it readily absorbs ammonia and other gases in sufficient amount to impart a considerable chlorine demand. Prior to use in each experiment the pH of the water was checked and if it was not at the pH desired it was adjusted with appropriate sterile reagents. It was also tested (1) for chlorine (if any amount was present the water was discarded), and (2) for chlorine demand. In testing for chlorine demand a calculated amount of chlorine, from a titrated solution, was added to a measured amount of the water, allowed to stand for 5 minutes, and the residual determined. If no loss occurred, the water was used. A loss of 0.01 p. p. m. was considered significant for our purposes and such waters were discarded.

Preparation of glassware.—Traces of material left on glassware interfered materially with sustained chlorine residuals. Even the residue from a few drops of tap water, used as a rinse, dried on the inside of a flask, or the condensate from the steam of autoclave sterilization was found at times to require as much as 0.01 to 0.05 p. p. m. of applied chlorine when 500 ml. of the prepared water was added to a 1-liter flask and tested. Therefore, glassware used in these tests not only was sterilized but also was made chemically clean. To accomplish this, all glassware was cleaned by strong chromic acid cleaning solution, rinsed ten times with tap water, followed by two rinses with distilled water, then dried and sterilized in dry, hot air.

Preparation of stock chlorine solution.—Chlorine solutions used in these studies were prepared from a stock solution of sodium hypochlorite (NaOCl). Portions of this stock solution were diluted to approximately the desired concentration (25 to 100 p. p. m.) with unbuffered chlorine-demand-free water. A 100-ml. sample of this diluted chlorine solution was taken and its chlorine content determined quantitatively by titration with 0.0282 N sodium thiosulfate ($Na_2S_2O_3$) using the acid-starch-iodide method. In this titration 1 ml. of $Na_2S_2O_3$ solution is the equivalent of 10 p. p. m. of chlorine when a 100-ml. sample is titrated. This dilute chlorine solution was prepared fresh before each test. In the tests, appropriate quantities of this titrated chlorine solution were added to each 500-ml. portion of chlorine-free, chlorine-demand-free water to give the concentration of chlorine desired.

Determination of free chlorine residual.—As indicated above, the initial chlorine concentrations for each test were determined by quantitative dilutions of a stock chlorine solution, which had been titrated by the starch-iodide method. These calculated chlorine con-

centrations were also read by the standard orthotolidine test, using 100 ml. of the sample (*10*). The latter was the only method used for the determination of chlorine residuals during the tests. Although the standard orthotolidine test does not differentiate between chlorine and chloramine, it was the only available test which could be used quantitatively. Moore (*2*), who presents such a differential test and reviews other tests, points out that none of these differential tests is accurately quantitative, especially in low concentrations. Consequently, the only criteria by which free chlorine could be assumed were that (1) all substances, other than the bacteria to be added, which are capable of reacting with chlorine had been removed, and (2) the maximum color developed by the orthotolidine reagent was produced almost immediately. The appearance of a definite color after 10 to 30 seconds of contact with the orthotolidine was considered as clear-cut evidence of the presence of free chlorine.

In the tests with pathogenic organisms, the procedure for the determination of residual chlorine was modified to eliminate the risk of contaminating the analyst. Samples for residual chlorine determinations containing pathogens were withdrawn with a sterile 100-ml. pipette and allowed to run into the Nessler tube simultaneously with the orthotolidine reagent. The tubes thus partially mixed were set aside for 5 minutes to provide for more complete mixing by gravity and diffusion. Although maximum color was attained in 1 to 2 minutes by this procedure with free chlorine, all readings were made after a reaction time of 5 minutes to standardize the procedure.

The only other deviation from the standard procedure was that 2 ml. of orthotolidine reagent were added instead of 1 ml. as specified in Standard Methods (*10*). This was considered necessary in order to counteract the buffer concentration of the test waters used.

Determination of hydrogen-ion concentration.—The hydrogen-ion concentration of the waters used was determined routinely by colorimetric procedures, using LaMotte color standards and indicators. These standards and occasional sets of samples were also checked electrometrically at intervals during the course of the tests.

Preparation of bacterial suspensions.—Eleven freshly isolated strains of five genera of bacteria were used in this study. This included two strains each of *Escherichia coli*, *Aerobacter aerogenes*, *Pseudomonas pyocyanea*, *Eberthella typhosa*, and three strains of *Shigella dysenteriae*. One of the *E. typhosa* strains was from a blood culture of a clinically typical case of typhoid fever and all three Shigellas were from the stools of typical cases of Shiga dysentery. In preparing suspensions of these bacteria, the entire surface of a standard agar slant was inoculated with a young culture of the organism under test and incubated for 20 to 24 hours at 37° C. The growth on this slant was carefully washed off with about 2 ml. of water and diluted to 100 ml.

with sterile dilution water. This first dilution was shaken vigorously and allowed to stand quiescent for about 10 minutes. An appropriate quantity of the first dilution was then transferred to a second 99-ml. portion of sterile dilution water and vigorously shaken. By "appropriate quantity" is meant that amount from the first dilution which would provide a bacterial population of about 800,000 per ml. in the second dilution bottle. This quantity varied somewhat (from 0.3 to 2.2 ml.) for the different cultures in use but this part of the work could be estimated quite accurately by the bacteriologist, who had had a very considerable experience in preparing this type of suspension. In all cases a 1-ml. portion of this second dilution was added to each test flask containing 400 ml. of water. Thus 1 ml. of suspension containing approximately 800,000 bacteria, added to 400 ml. of sterile chlorine-demand-free water, provided a mixture containing a calculated number of 2,000 bacteria per ml. This approximate density of bacterial population was selected for these tests because (1) it was a suitable number for making counts and measuring decreases; (2) it was not in excess of the number which might be expected in many waters; and (3) preliminary tests had shown that bacterial mixtures as prepared, containing up to 50,000 organisms per ml., exercised no measurable demand on calculated additions of free chlorine.

It is of interest to note here as an illustration of the consistency of the initial bacterial numbers that in 20 of 21 series of tests conducted with *Esch. coli* strains, the average initial bacterial content was 2,330 per ml. with a maximum count of 3,960 per ml. and a minimum count of 2,040 per ml. In the other coli series, apparently due to a decimal error in the preparation of the suspension, the initial count was only 302 per ml. However, the results in this series, as well as in preliminary tests with initials up to 50,000 bacteria per ml., did not show any skew deviations in residual chlorine or in the decrease of bacterial numbers. In 16 series of tests with *E. typhosa* strains, the average initial was 1,930 organisms per ml. with a maximum of 3,620 and a minimum of 1,060 per ml., while in 10 series with *Ps. pyocyanea* the average initial number per ml. was 1,990, with a maximum of 2,380 and a minimum of 1,620 per ml. In five series of tests with *S. dysenteriae* and four with *A. aerogenes*, the average, maximum, and minimum initial numbers of organisms per ml. were 1,940, 2,410, 1,360, and 1,770, 4,320, and 1,100, respectively.

Bacterial counts.—Quantitative determinations of the number of bacteria per ml. were made by agar plate counts. In this, the procedures given in Standard Methods (*10*) were followed with two exceptions or additions. Instead of planting two plates with the required quantity of sample, eight plates were made for the initial count from the control flask, which received no chlorine, and four

initial plates from each of the other chlorine-bearing flasks in each series. For each examination made at various intervals subsequent to the initial, four plates were made of the control flask and duplicate plates (two 1-ml. and two $\frac{1}{10}$-ml. plates) from each of the other flasks. Routine sterility examinations of the water, pipettes, petri dishes, and agar were made for each test. Plates were incubated for 24 hours at 37° C. and counted with the aid of a Quebec colony counter. Plates which showed a zero count or a markedly reduced number of colonies were incubated for an additional 24 hours and reexamined to check on the possibility of delayed growth. Representative colonies, or all of the colonies if less than 10, on plates showing marked reductions from the initial, were picked and subjected to appropriate identification before final certification of the results. Incidental colonies of airborne bacteria, never more than one or two colonies per plate, were encountered only rarely.

Neutralization of chlorine.—As the bactericidal action of the chlorine would continue until it was spent or neutralized, it was necessary when using a plating procedure to have some method of stopping the chlorine action at the exact time interval desired. This was particularly important for the short-time periods of examination, 1, 3, 5, and 10 minutes. To provide for this step, measured quantities of sterile, 2-percent peptone solution were prepared. Just prior to the required time of examination a volume of the water being tested, equal to the measured amount of peptone solution, was removed from the flask with a sterile rapid delivery pipette and, exactly at the desired time, added to the peptone solution with immediate mixing. Preliminary tests indicated that this stopped chlorine action and provided the necessary time for plating the sample in a correct manner. The resultant dilution by the peptone water was compensated by plating double quantities of such portions.

TEST PROCEDURES

In this study, utilizing the materials, equipment, and methods described, 56 series of tests were performed in addition to the preliminary exploratory experiments. In each series three bacteriologists and one chemist cooperated simultaneously, one making the additions of bacteria, chlorine, and mixing, another keeping the time record, withdrawing bacteriological samples, and neutralizing, a third bacteriologist planting the samples, and the chemist making the residual chlorine and pH examinations. A "series" consisted of repeated observations on eight test portions of water. Two portions served as controls. These two were identical with the other six portions and were treated in exactly the same manner except that one did not receive any chlorine and the other did not receive any bacteria. The

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other six portions received varying amounts of previously standardized chlorine solution. Bacterial plate counts were made on portions from the chlorine-bearing flasks at the start and either at the 1-, 3-, 5-, 10-, 15-, 30-, 60-, 90-, and 120-minute intervals or at the 1-, 3-, 5-, 10-, 20-, and 60-minute intervals depending on the bacterial death rate. Observations on the control flasks were made at all intervals except the 1-, 3-, and 5-minute periods. Residual chlorine determinations were made at the start, at the end of 1 hour, and at 2 hours if the test was continued for 2 hours.

In setting up a test 500 ml. of sterile, chlorine-free, chlorine-demand-free water were added to each of eight sterile, 1-liter Erlenmeyer flasks. From one of these, the control flask, 100 ml. were removed and tested for chlorine. One ml. of the standardized bacterial suspension was then added to this flask, the contents thoroughly mixed, and portions removed for making the initial counts. A second flask, also serving as a control, received a known amount of chlorine and was tested for residual chlorine after 5 minutes standing at the desired temperature and at intervals thereafter. This flask also was equipped with a thermometer to provide for temperature readings.

The remaining six flasks were dosed with chlorine in varying amounts, depending on the requirements of the particular test. A time interval was allowed between the dosing of each flask with chlorine so that there would be no conflict in the time for subsequent examinations of the contents of the various flasks. As soon as the titrated amount of chlorine had been added to each flask, its contents were thoroughly mixed and 5 minutes later a 100-ml. portion was removed for a residual chlorine determination. Simultaneously with the fixing of the chlorine in this test portion with orthotolidine, the 1 ml. of bacterial suspension was added to the remaining 400 ml. in the flask, mixed quickly and thoroughly, the time was noted, and portions were removed for examination at the indicated intervals. A time schedule was prepared for each flask in a series to insure accuracy in the times of sampling. For all series conducted at 2° to 5° C. and at 20° to 25° C. (when room temperatures were not in this range), the flasks were kept in a water bath with the temperature maintained.

RESULTS

In conducting these 56 series of tests, an effort was made to extend the range of the observations to the limits which might be encountered in practical operation, with the thought that the results, even though limited in scope, might serve as a general guide. Thus, with regard to the hydrogen-ion concentrations, most of the tests were conducted at pH 7.0, 8.5, 9.8, and 10.7 with exploratory experiments at pH 6.5 and 7.8. Two temperature ranges were investigated, 2° to 5° C. and 20° to 25° C., ranges which might be considered the average extremes

met in nature. It is recognized that the work is incomplete in that (1) a greater number of bacterial strains should have been used, and (2) additional temperatures and pH ranges should have been investigated. Time did not permit this more extended study, however, and the results submitted may serve as a guide for the intermediate ranges. It can be definitely stated, at least, that the data presented were carefully determined and that, without question, they represent the action of free chlorine without the interference of any chlorine-addition products. It is noted that in some instances other factors, such as hydrogen-ion concentration (particularly in the tests at pH 9.8 and 10.7), may have also played a part in bacterial decrease; however, as shown in the reference cited (*3*), the rate of bacterial kill induced by pH effects is quite slow as compared with chlorine action. It should be reemphasized at this time that the results presented here were secured with free chlorine, and that free chlorine is a much more effective bactericidal agent than an equivalent amount of chloramine or any combination of chlorine and chloramine, as has been pointed out by Streeter (*1*) and many others.

The average results obtained with each range of residual chlorine concentration, under all conditions tried, from these 56 series of tests are presented in six tables. Table 1 gives the average results obtained with all *Esch. coli* strains, and tables 2, 3, 4, and 5, the results for *A. aerogenes*, *Ps. pyocyanea*, *E. typhosa*, and *S. dysenteriae*, respectively. Table 6 is a compilation showing the time in minutes required to produce a 100-percent kill under the various conditions.

TABLE 1.—*Average survival of* Esch. coli, *expressed in percent of initial number when exposed to chlorine in various concentrations at pH 7.0, 8.5, 9.8, and 10.7 when held at 2° to 5° C., and at 20° to 25° C.*

Number of strains	Number of tests	Average percentage surviving after varying exposures										Average chlorine p. p. m. after exposure		
		1 min.	3 min.	5 min.	10 min.	15 min.	20 min.	30 min.	60 min.	90 min.	120 min.	0 min.	60 min.	120 min.
2° to 5° C. pH 7.0														
1	2	100.0	------	------	------	99.4	------	98.2	88.6	90.1	96.0	0.00	------	0.00
1	2	96.1	95.4	92.0	[1]85.4	78.8	------	83.0	76.8	70.0	71.8	0.02	------	0.02
1	2	80.0	9.6	0.1	[1]0.0	0.0	------	0.0	0.0	0.0	0.0	0.03	------	0.02
1	2	70.2	0.0	0.0	------	0.0	------	0.0	0.0	0.0	0.0	0.04	------	0.04
1	2	40.5	0.0	0.0	------	0.0	------	0.0	0.0	0.0	0.0	0.05	------	0.04
1	2	0.0	0.0	0.0	------	0.0	------	0.0	0.0	------	------	0.10	0.09	------
pH 8.5														
1	2	100.0	------	------	89.5	------	91.5	------	76.3	------	------	0.00	0.00	------
1	2	94.6	81.4	70.3	20.9	------	0.3	------	0.0	------	------	0.05	0.04	------
1	2	86.0	59.6	25.8	0.5	------	0.0	------	0.0	------	------	0.07	0.06	------
1	8	57.3	11.1	0.7	0.0	------	0.0	------	0.0	------	------	0.14	0.12	------

[1] Interpolated figure.

TABLE 1.—*Average survival of* Esch. coli, *expressed in percent of initial number, when exposed to chlorine in various concentrations at pH 7.0, 8.5, 9.8, and 10.7 when held at 2° to 5° C., and at 20° to 25° C.*—Continued

Number of strains	Number of tests	Average percentage surviving after varying exposures										Average chlorine p. p. m. after exposure		
		1 min.	3 min.	5 min.	10 min.	15 min.	20 min.	30 min.	60 min.	90 min.	120 min.	0 min.	60 min.	120 min.
pH 9.8														
1	2	100.0			88.9		92.8		72.6			0.00	0.00	
1	2	83.8	82.3	79.6	79.5		70.2		42.4			0.05	0.05	
1	4	89.2	73.7	73.4	47.5		19.4		0.1			0.15	0.15	
1	2	90.3	65.6	36.1	2.2		0.0		0.0			0.40	0.40	
1	2	77.6	32.6	4.8	0.0		0.0		0.0			0.72	0.72	
1	2	56.4	2.6	0.1	0.0		0.0		0.0			1.00	1.00	
pH 10.7														
1	2	100.0			87.4		79.5		51.0			0.00	0.00	
1	2	98.3	92.6	91.0	92.6		59.2		37.9			0.10	0.10	
1	2	96.6	92.4	76.6	54.7		13.0		0.0			0.30	0.30	
1	2	99.2	89.3	82.4	44.6		8.4		0.0			0.40	0.40	
1	2	97.1	94.8	74.0	36.4		5.1		0.0			0.50	0.50	
1	2	90.8	95.7	58.5	22.2		1.7		0.0			0.75	0.75	
1	2	95.5	82.7	50.8	9.4		0.2		0.0			1.00	1.00	
20° to 25° C.														
pH 7.0														
2	3	98.6				100.0		96.6	94.8	97.5	96.8	0.00		0.00
2	4	29.1	16.2	19.4	[1] 18.0	17.7		18.6	19.4	[1] 17.5	15.6	0.02	0.01	Tr.
2	4	16.1	0.8	0.8	[1] 0.6	0.3		0.2	0.8	0.1	0.1	0.03	0.02	0.01
1	2	0.0	0.0	0.0	[1] 0.0	0.0		0.0	0.0	0.0	0.0	0.04	0.03	0.02
2	3	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.05	0.04	0.03
2	3	0.0	0.0	0.0		0.0		0.0	0.0			0.07	0.06	
2	2	0.0	0.0	0.0		0.0		0.0	0.0			0.10	0.10	
pH 8.5														
1	2	100.0			94.6		92.4		95.4			0.00	0.00	
1	2	90.0	64.1	29.6	1.2		0.2		0.0			0.05	0.05	
1	2	87.0	5.9	0.2	0.0		0.0		0.0			0.07	0.07	
1	8	29.5	0.1	0.1	0.0		0.0		0.0			0.14	0.14	
pH 9.8														
1	4	100.0			97.0		91.9		69.0			0.00	0.00	
1	1	83.2	99.1	76.1	81.4		56.2		5.8			0.02	0.02	
1	3	93.4	88.5	70.7	56.8		44.7		9.5			0.04	0.04	
1	2	80.0	67.6	33.5	2.0		0.0		0.0			0.06	0.06	
1	2	85.4	43.0	7.8	0.2		0.0		0.0			0.08	0.08	
1	9	65.7	30.4	13.7	2.8		0.0		0.0			0.14	0.13	
1	2	58.3	3.1	0.0	0.0		0.0		0.0			0.30	0.26	
1	2	48.3	0.4	0.0	0.0		0.0		0.0			0.40	0.38	
1	1	59.4	0.0	0.0	0.0		0.0		0.0			0.50	0.46	
1	1	5.8	0.0	0.0	0.0		0.0		0.0			0.75	0.75	
1	1	0.0	0.0	0.0	0.0		0.0		0.0			1.00	1.00	
pH 10.7														
1	4	100.0			93.4		78.2		44.4			0.00	0.00	
1	2	97.8	95.7	90.5	73.9		44.6		6.4			0.02	0.02	
1	1	92.2	65.5	79.3	45.7		9.0		0.0			0.03	0.03	
1	1	72.4	74.1	64.6	31.2		2.8		0.0			0.04	0.04	
1	1	85.3	82.8	64.6	16.2		0.2		0.0			0.05	0.05	
1	2	85.8	74.5	67.2	35.2		9.0		0.0			0.06	0.06	
1	6	86.6	75.7	39.5	7.9		0.4		0.0			0.16	0.16	
1	3	87.9	33.2	8.3	0.3		0.0		0.0			0.30	0.29	
1	3	81.4	18.0	3.0	0.0		0.0		0.0			0.40	0.40	
1	3	74.8	9.6	0.6	0.0		0.0		0.0			0.53	0.52	
1	1	37.7	2.6	0.0	0.0		0.0		0.0			0.75	0.75	
1	1	31.8	0.7	0.7	0.0		0.0		0.0			1.00	1.00	

[1] Interpolated figure.

TABLE 2.—*Average survival of* A. aerogenes, *expressed in percent of initial number, when exposed to chlorine in various concentrations at pH 7.0 when held at 20° to 25° C.*

Number of strains	Number of tests	Average percentage surviving after varying exposures										Average chlorine p. p. m. after exposure		
		1 min.	3 min.	5 min.	10 min.	15 min.	20 min.	30 min.	60 min.	90 min.	120 min.	0 min.	60 min.	120 min.
2	4	100.0	------	------	------	95.5	------	96.7	97.7	96.3	97.3	0.00	0.00	0.00
2	4	82.8	85.4	79.4	[1]82.8	86.2	------	72.1	77.5	77.0	67.9	0.02	0.02	0.01
1	2	93.2	80.2	70.8	[1]63.8	56.9	------	51.2	46.9	34.1	21.5	0.03	------	0.02
2	4	62.3	38.7	32.4	[1]32.0	31.6	------	27.8	21.5	19.0	10.0	0.04	0.03	0.03
1	2	57.6	1.4	0.2	[1]0.1	0.0	------	0.0	0.0	0.0	0.0	0.05	------	0.04
2	3	14.5	0.4	0.6	[1]0.5	0.4	------	0.4	0.1	0.0	0.0	0.06	0.05	0.05
2	2	0.0	0.0	0.0	[1]0.0	0.0	------	0.0	0.0	------	------	0.08	0.08	0.07
2	6	0.1	0.0	0.0	------	0.0	------	0.0	0.0	0.0	0.0	0.12	0.12	0.08

[1] Interpolated figure.

TABLE 3.—*Average survival of* Ps. pyocyanea, *expressed in percent of initial number, when exposed to chlorine in various concentrations at pH 7.0, 8.5, 9.8, and 10.7 when held at 20° to 25° C.*

Number of strains	Number of tests	Average percentage surviving after exposure										Average chlorine p. p. m. after exposure		
		1 min.	3 min.	5 min.	10 min.	15 min.	20 min.	30 min.	60 min.	90 min.	120 min.	0 min.	60 min.	120 min.
pH 7.0														
2	4	100.0	------	------	------	97.1	------	96.3	95.4	95.4	88.6	0.00	0.00	0.00
2	10	79.1	63.9	47.6	[1]45.4	43.1	------	43.0	40.6	37.7	32.2	0.01	0.01	Tr.
2	3	40.6	0.3	0.0	[1]0.0	0.0	------	0.0	0.0	0.0	0.0	0.03	0.02	0.02
2	2	5.2	0.0	0.0	------	0.0	------	0.0	0.0	0.0	0.0	0.04	0.03	0.03
2	4	0.0	0.0	0.0	------	0.0	------	0.0	0.0	0.0	0.0	0.05	0.04	0.04
2	4	0.0	0.0	0.0	------	0.0	------	0.0	0.0	0.0	0.0	0.06	0.05	0.05
pH 8.5														
1	2	100.0	------	------	99.2	------	99.7	------	98.2	------	------	0.00	0.00	------
1	1	91.4	100.0	88.9	88.9	------	75.3	------	61.7	------	------	0.03	0.03	------
1	2	93.4	86.4	73.4	34.4	------	34.6	------	14.6	------	------	0.04	0.04	------
1	2	78.2	77.9	33.9	1.8	------	0.0	------	0.0	------	------	0.06	0.05	------
1	1	89.6	75.5	9.1	0.0	------	0.0	------	0.0	------	------	0.08	0.05	------
1	6	80.1	1.3	0.0	0.0	------	0.0	------	0.0	------	------	0.15	0.14	------
pH 9.8														
1	2	100.0	------	------	97.4	------	88.7	------	82.6	------	------	0.00	0.00	------
1	1	91.1	94.5	82.7	96.6	------	79.7	------	40.5	------	------	0.03	0.03	------
1	2	73.6	83.8	84.6	78.7	------	59.6	------	24.8	------	------	0.05	0.04	------
1	1	80.2	70.0	70.0	43.0	------	4.0	------	0.0	------	------	0.08	0.08	------
1	7	69.1	68.4	45.4	13.2	------	0.5	------	0.0	------	------	0.17	0.16	------
1	1	41.9	47.4	12.7	0.0	------	0.0	------	0.0	------	------	0.40	0.35	------
pH 10.7														
1	2	100.0	------	------	87.9	------	86.0	------	73.0	------	------	0.00	0.00	------
1	1	90.8	85.7	95.4	62.2	------	76.8	------	32.4	------	------	0.05	0.04	------
1	4	67.4	72.3	66.8	37.4	------	31.0	------	0.0	------	------	0.17	0.16	------
1	2	75.6	77.0	49.3	2.1	------	0.0	------	0.0	------	------	0.30	0.28	------
1	2	68.6	69.0	31.6	0.4	------	0.0	------	0.0	------	------	0.40	0.38	------
1	1	67.4	61.6	16.3	0.3	------	0.0	------	0.0	------	------	0.50	0.50	------
1	1	73.7	34.7	9.4	0.0	------	0.0	------	0.0	------	------	0.75	0.70	------
1	1	72.1	28.4	2.4	0.0	------	0.0	------	0.0	------	------	1.00	1.00	------

[1] Interpolated figure.

TABLE 4.—*Average survival of* E. typhosa, *expressed in percent of initial number, when exposed to chlorine in various concentrations at pH 7.0, 8.5, 9.8, and 10.7, when held at 2° to 5° C. and at 20° to 25° C.*

Number of strains	Number of tests	Average percentage surviving after exposure										Average chlorine p. p. m. after exposure		
		1 min.	3 min.	5 min.	10 min.	15 min.	20 min.	30 min.	60 min.	90 min.	120 min.	0 min.	60 min.	120 min.
2° to 5° C.														
pH 7.0														
1	2	100.0	------	------	------	95.9	------	100.0	100.0	92.0	88.8	0.00	------	0.00
1	2	86.4	75.1	56.2	[1]47.2	38.6	[1]34.9	27.4	19.9	16.8	8.0	0.02	------	0.02
1	2	67.1	2.3	0.1	[1]0.0	0.0	------	0.0	0.0	0.0	0.1	0.03	------	0.03
1	2	36.2	0.0	0.0	------	0.0	------	0.0	0.0	0.0	0.0	0.04	------	0.04
1	1	8.2	0.0	0.0	------	0.0	------	0.0	0.0	0.0	0.0	0.05	------	0.05
1	3	10.6	0.0	0.0	------	0.0	------	0.0	0.0	0.0	0.0	0.06	0.06	0.06
1	2	0.0	0.0	0.0	------	0.0	------	0.0	0.0	------	------	0.08	0.08	------
pH 9.8														
1	2	100.0	------	------	88.6	------	77.8	------	75.2	------	------	0.00	0.00	------
1	2	80.8	79.6	75.6	54.6	------	43.6	------	19.8	------	------	0.05	0.04	------
1	4	77.2	68.2	48.8	24.9	------	4.4	------	0.0	------	------	0.15	0.15	------
1	2	54.2	32.7	15.1	0.1	------	0.0	------	0.0	------	------	0.40	0.36	------
1	2	42.4	18.4	1.6	0.0	------	0.0	------	0.0	------	------	0.74	0.74	------
1	2	36.4	2.2	0.0	0.0	------	0.0	------	0.0	------	------	1.00	1.00	------
20° to 25° C.														
pH 7.0														
2	5	100.0	------	------	------	96.2	------	98.4	99.0	96.9	96.6	0.00	0.00	0.00
2	6	82.7	77.6	72.3	[1]68.5	64.7	[1]63.5	61.0	48.4	49.3	41.1	0.02	------	0.01
2	4	71.0	33.8	27.2	[1]25.4	23.6	[1]24.0	25.0	22.0	19.0	13.5	0.03	------	0.02
2	5	16.8	1.3	0.1	[1]0.1	0.0	[1]0.0	0.0	0.0	0.0	0.0	0.04	------	0.04
2	4	8.9	6.9	4.8	[1]2.9	1.1	[1]0.8	0.1	0.0	0.0	0.0	0.05	------	0.04
2	5	6.0	0.0	0.0	[1]0.0	0.0	[1]0.0	0.0	0.0	0.0	0.0	0.06	0.06	0.06
2	5	1.0	0.0	0.0	[1]0.0	0.0	------	0.0	0.0	0.0	0.0	0.08	0.07	0.07
1	1	0.0	0.0	0.0	[1]0.0	0.0	------	0.0	0.0	------	------	0.15	0.13	------
pH 8.5														
1	2	100.0	------	------	95.7	------	93.1	------	87.5	------	------	0.00	0.00	------
1	1	81.6	47.7	13.2	0.4	------	0.3	------	6.0	------	------	0.03	0.02	------
1	2	70.2	2.4	0.0	0.0	------	0.0	------	0.0	------	------	0.06	0.04	------
1	2	42.8	0.1	0.0	0.0	------	0.0	------	0.0	------	------	0.08	0.06	------
1	7	3.9	0.0	0.0	0.0	------	0.0	------	0.0	------	------	0.15	0.14	------
20° to 25° C.														
pH 9.8														
1	2	100.0	------	------	72.5	------	61.2	------	28.0	------	------	0.00	0.00	------
1	1	93.1	85.6	55.2	7.7	------	0.7	------	0.0	------	------	0.05	0.05	------
1	4	62.2	11.4	0.6	0.0	------	0.0	------	0.0	------	------	0.16	0.16	------
1	2	26.0	0.0	0.0	0.0	------	0.0	------	0.0	------	------	0.30	0.26	------
1	2	17.0	0.0	0.0	0.0	------	0.0	------	0.0	------	------	0.40	0.36	------
1	1	6.0	0.0	0.0	0.0	------	0.0	------	0.0	------	------	0.50	0.46	------
1	1	0.3	0.0	0.0	0.0	------	0.0	------	0.0	------	------	0.75	0.65	------
1	1	0.0	0.0	0.0	0.0	------	0.0	------	0.0	------	------	1.00	0.90	------
pH 10.7														
1	3	100.0	------	------	47.1	------	27.3	------	10.5	------	------	0.00	0.00	------
1	2	92.8	82.8	78.6	48.8	------	18.0	------	0.4	------	------	0.01	0.01	------
1	1	97.8	69.3	61.4	20.7	------	1.3	------	0.0	------	------	0.03	0.02	------
1	2	85.4	62.9	35.9	5.6	------	0.3	------	0.0	------	------	0.04	0.04	------
1	2	88.8	65.6	21.2	0.9	------	0.1	------	0.0	------	------	0.06	0.06	------
1	4	92.0	38.5	11.5	0.8	------	0.0	------	0.0	------	------	0.18	0.15	------
1	2	72.6	6.3	0.1	0.0	------	0.0	------	0.0	------	------	0.30	0.26	------
1	2	65.4	1.9	0.0	0.0	------	0.0	------	0.0	------	------	0.40	0.38	------
1	1	47.8	0.7	0.0	0.0	------	0.0	------	0.0	------	------	0.50	0.50	------
1	1	31.8	0.0	0.0	0.0	------	0.0	------	0.0	------	------	0.75	0.75	------
1	1	8.2	0.0	0.0	0.0	------	0.0	------	0.0	------	------	1.00	1.00	------

[1] Interpolated figure.

TABLE 5.—*Average survival of* S. dysenteriae, *expressed in percent of initial number when exposed to chlorine in various concentrations at pH 7.0 when held at 20° to 25° C*

Number of strains	Number of tests	Average percentage surviving after exposure										Average chlorine p. p. m. after exposure		
		1 min.	3 min.	5 min.	10 min.	15 min.	20 min.	30 min.	60 min.	90 min.	120 min.	0 min.	60 min.	120 min.
3	5	100.0	------	------	------	98.9	------	90.5	94.4	83.2	84.4	0.00	0.00	0.00
3	5	85.7	76.6	75.1	[1]71.2	67.4	------	56.4	28.7	30.5	22.4	0.01	------	0.01
3	4	50.6	27.6	25.7	[1]24.0	22.2	------	23.2	17.0	10.8	4.3	0.03	------	0.03
3	5	51.9	23.9	15.6	[1]12.0	9.5	------	4.8	0.1	0.1	0.0	0.04	------	0.04
3	4	0.2	0.0	0.0	[1]0.0	0.0	------	0.0	0.0	0.0	0.0	0.05	0.05	0.04
3	3	13.2	0.0	0.0	------	0.0	------	0.0	0.0	0.0	0.0	0.06	0.06	0.05
3	3	1.0	0.0	0.0	------	0.0	------	0.0	0.0	------	------	0.08	0.08	------

[1] Interpolated figure.

TABLE 6.—*Time in minutes required to produce a 100-percent kill of bacteria when exposed to chlorine and various hydrogen-ion concentrations at two temperatures*

Chlorine range p. p. m.	pH 7.0					pH 8.5			pH 9.8			pH 10.7		
	Esch. coli	*A. aerogenes*	*Ps. pyocyanea*	*E. typhosa*	*S. dysenteriae*	*Esch. coli*	*Ps. pyocyanea*	*E. typhosa*	*Esch. coli*	*Ps. pyocyanea*	*E. typhosa*	*Esch. coli*	*Ps. pyocyanea*	*E. typhosa*
2° to 5° C.														
0.010–0.025	>120	------	------	>120	------	------	------	------	------	------	------	------	------	------
0.026–0.035	[1]10	------	------	[2]10	------	------	------	------	------	------	------	------	------	------
0.036–0.045	3	------	------	3	------	------	------	------	------	------	------	------	------	------
0.046–0.055	3	------	------	3	------	60	------	------	>60	------	>60	------	------	------
0.056–0.070	------	------	------	3	------	20	------	------	------	------	------	------	------	------
0.071–0.099	------	------	------	1	------	------	------	------	------	------	------	------	------	------
0.10–0.29	1	------	------	------	------	10	------	------	>60	------	60	>60	------	------
0.30–0.39	------	------	------	------	------	------	------	------	------	------	------	60	------	------
0.40–0.49	------	------	------	------	------	------	------	------	20	------	20	60	------	------
0.50–0.69	------	------	------	------	------	------	------	------	------	------	------	60	------	------
0.70–0.99	------	------	------	------	------	------	------	------	10	------	10	60	------	------
1.00	------	------	------	------	------	------	------	------	10	------	5	60	------	------
20° to 25° C.														
0.010–0.025	>120	>120	>120	>120	>120	------	------	------	>60	------	------	>60	------	------
0.026–0.035	>120	>120	5	>120	>120	------	>60	>60	------	>60	------	60	------	60
0.036–0.045	1	>120	3	15	120	------	>60	------	>60	------	------	60	------	60
0.046–0.055	1	15	1	60	3	60	------	------	------	60	60	60	>60	[3]60
0.056–0.070	1	90	1	3	3	10	20	5	20	------	------	60	------	60
0.071–0.099	[1]1	1	------	3	3	[1]10	10	5	20	60	------	[3]60	------	------
0.10–0.29	1	3	------	1	------	10	5	3	20	60	5	60	60	20
0.30–0.39	------	------	------	------	------	------	------	------	5	------	3	20	20	10
0.40–0.49	------	------	------	------	------	------	------	------	5	10	3	10	20	5
0.50–0.69	------	------	------	------	------	------	------	------	3	------	3	10	20	5
0.70–0.99	------	------	------	------	------	------	------	------	3	------	3	5	10	3
1.00	------	------	------	------	------	------	------	------	1	------	1	10	10	3

[1] Interpolated figure.
[2] One typical colony found on 2-hour plate after 10-, 15-, 30-, 60-, and 90-minute tests were sterile.

DISCUSSION OF RESULTS

For purposes of discussion of the results obtained and of demonstrating the influence of certain variable factors on the resistance of the vegetative cells of bacteria to free chlorine, portions of the data presented in the tables have been shown graphically. Because of the number of variables involved, all of the data concerned with one variable could not be shown in any one chart without confusion. Conse-

quently, the data selected for presentation in the charts, though demonstrating the particular point in question, may not meet the full requirements of a particular situation. For example, in some of the charts are shown the effects of pH and of temperature on the survival of certain bacteria when exposed to free chlorine for periods of 5 and 10 minutes. The inclusion of corresponding data for time periods of 1, 3, 20, and 60 minutes in these charts would have made them too complicated. If the data plotted do not fit the particular needs of the reader in this respect, other data may be selected from the tables and similarly plotted.

EFFECT OF TIME OF EXPOSURE

In figures 1A to 1D, inclusive, the percentage survival of *Esch. coli* is plotted against time in minutes for four different hydrogen-ion concentrations, in two divergent temperature ranges. In figure 1A it is noted that at pH 7.0, 0.02 p.p.m. of free chlorine was not sufficient to produce a 100-percent kill at either temperature during a 60-minute period of exposure, whereas it did produce an approximately 80-percent kill in 5 minutes at room temperature, with no further kill thereafter, and a more gradual kill at 2° to 5° C. of about 23 percent during the first hour. Under the same conditions, however, 0.04 p.p.m. effected a 100-percent kill in 1 minute at the higher temperature and 0.05 p.p.m. a 100-percent kill in 3 minutes at the lower temperature. Thus at pH 7.0 and at temperatures ranging from 2° to 25° C. the critical effective dosage of free chlorine for *Esch. coli* is indicated to be in the range of 0.02 to 0.05 p.p.m., with 0.02 p.p.m. definitely shown to be insufficient to produce a 100-percent kill under the most favorable conditions. The critical dosage is probably 0.03 to 0.04 p.p.m.

Similarly in figures 1B, 1C, and 1D are shown corresponding results of averages for *Esch. coli* obtained at pH 8.5. 9.8, and 10.7 respectively. At pH 8.5, sharp reductions were observed with 0.05 and 0.07 p.p.m. of chlorine at both temperatures, the rate of decline varying with the amount of chlorine and the temperature. The indicated rate was slowest with 0.05 p.p.m. at 2° to 5° C. producing about an 80-percent kill in 10 minutes, 99 percent in 20 minutes, and 100 percent sometime between 20 minutes and 1 hour. With 0.07 p.p.m. a 100-percent kill was obtained in 10 minutes at 20° to 25° C., and in 20 minutes at 2° to 5° C. Thus at pH 8.5 at least 0.07 p.p.m. of chlorine was required to obtain a 100-percent kill of *Esch. coli* in 10 to 20 minutes in the temperature ranges covered.

In figure 1C, at pH 9.8 chlorine concentrations of 0.05 and 0.04 p.p.m. at 2° to 5° C. and 20° to 25° C., respectively, were quite inadequate to produce a 100-percent kill even in 60 minutes. It is observed also that the rate of kill for these chlorine concentrations at this pH, though faster at the higher temperature, was much more gradual than was observed at pH 7.0 and 8.5. In fact, the rates at these two con-

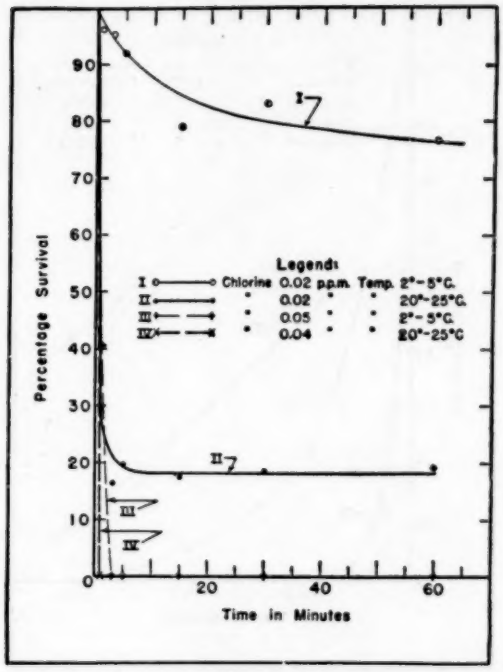

FIGURE 1A.—Percentage survival of *Esch. coli* exposed to chlorine in various concentrations, at pH 7.0, and at two temperatures, 2°–5° C. and 20°–25° C.

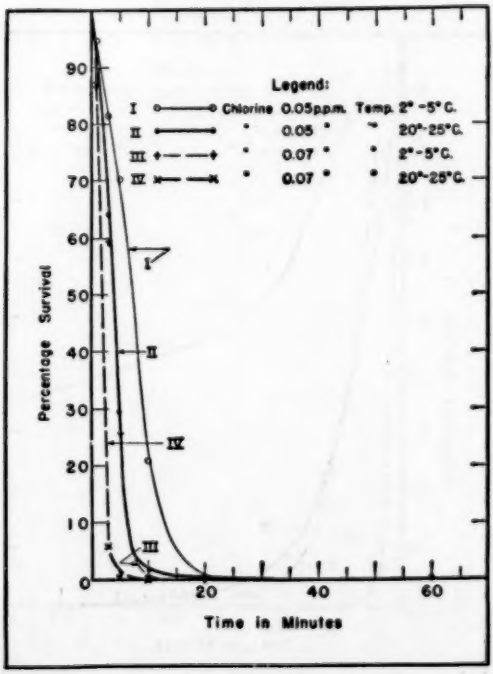

FIGURE 1B.—Percentage survival of *Esch. coli* exposed to chlorine in various concentrations, at pH 8.5, and at two temperatures, 2°–5° C. and 20°–25° C.

558145°—43——3

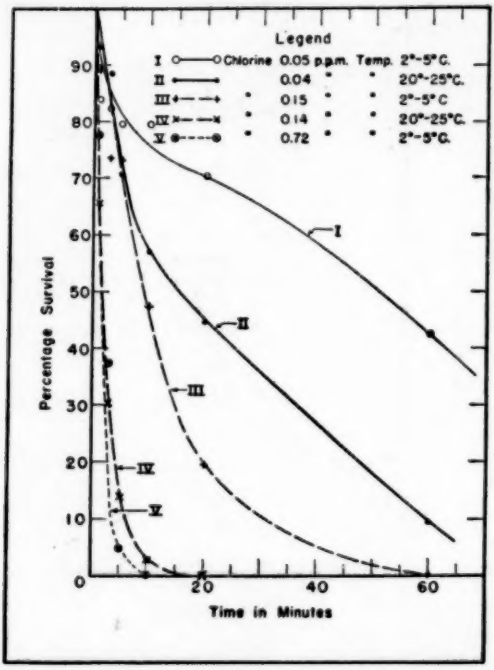

FIGURE 1C.—Percentage survival of *Esch. coli* exposed to chlorine in various concentrations, at pH 9.8, and at two temperatures, 2°–5° C. and 20°–25° C.

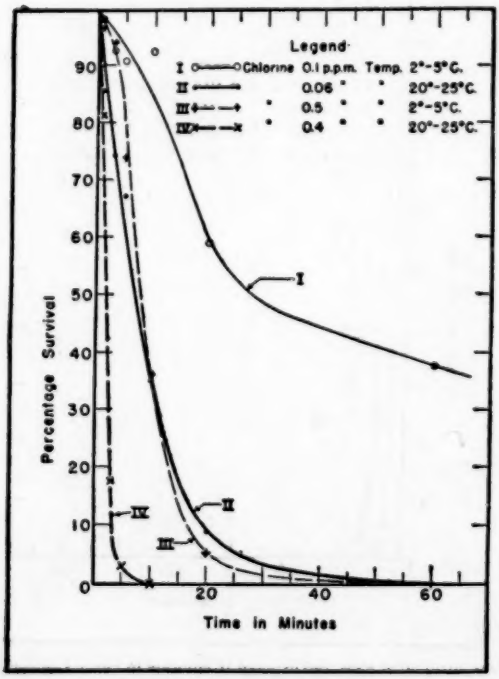

FIGURE 1D.—Percentage survival of *Esch. coli* exposed to chlorine in various concentrations, at pH 10.7, and at two temperatures, 2°–5° C. and 20°–25° C.

centrations of chlorine as indicated by curves I and II of figure 1C and at 0.15 p.p.m. at 2° to 5° C. (curve III) were so gradual they do not suggest the effect of an active bactericidal agent such as chlorine. At this pH, 9.8, it was necessary to increase the chlorine concentration to 0.15 p.p.m. at 20° to 25° C. and to 0.72 at 2° to 5° C. before the rate of decrease of *Esch. coli* became sufficiently rapid to bring about a 100-percent kill in 10 to 20 minutes.

In curves I, II, and III of figure 1D, prepared from the average results obtained with waters at pH 10.7, the same gradual decrease in the numbers of *Esch. coli* is observed. This is particularly marked in curve I, where, with 0.1 p.p.m. of chlorine present, about 90 percent of the *Esch. coli* survived for 10 minutes, 59 percent for 20 minutes, and 38 percent remained alive after 1 hour of exposure at 2° to 5° C. It was only when 0.4 p.p.m. of chlorine was used at 20° to 25° C. that a bacterial kill of 100 percent occurred in 10 minutes, and at 2° to 5° C. a residual of 0.5 p.p.m. apparently required about 60 minutes to produce a 100-percent kill.

EFFECT OF PH VARIATION

Figures 2A, 2B, and 2C are presented to show the effect of various hydrogen-ion concentrations on the bactericidal efficiency of free chlorine. In these, to avoid complication, the time variable has been omitted from consideration, all results presented being those obtained after a 10-minute exposure, and the percentages of survival in waters of pH 7.0, 8.5, 9.8, and 10.7 being plotted against residual chlorine expressed in p.p.m. In figures 2A and 2B results are shown for *Esch. coli* at 2° to 5° C. and at 20° to 25° C., respectively. Results obtained with *E. typhosa* at pH 7.0 and 9.8 are presented for both temperature ranges in figure 2C. The marked effect of pH on bactericidal efficiency is clearly indicated. For instance, in figure 2A with results from waters held at 2° to 5° C. a 100-percent kill of *Esch. coli* was obtained at pH 7.0 with 0.03 p.p.m. of chlorine, while for the same kill at pH 8.5, 9.8, and 10.7 concentrations of chlorine of 0.14, 0.72, and more than 1.0 p.p.m., respectively, were required. In the temperature range of 20° to 25° C. (fig. 2B), the pH effect was not so marked, but at pH 7.0, 8.5, 9.8, and 10.7 chlorine concentrations of 0.04, 0.07, 0.3, and 0.4 p.p.m., respectively, were required to obtain a 100-percent kill in 10 minutes. From figure 2C it is noted that in order to obtain a 100-percent kill of *E. typhosa* at 2° to 5° C. in 10 minutes at pH 7.0, only 0.03 p.p.m. was needed, whereas at pH 9.8, 0.4 to 0.74 p.p.m. was required. In the 20° to 25° C. temperature range with *E. typhosa*, under otherwise similar conditions, 0.06 p.p.m. of chlorine at pH 7.0 and 0.16 p.p.m. at pH 9.8 were required to obtain the same results.

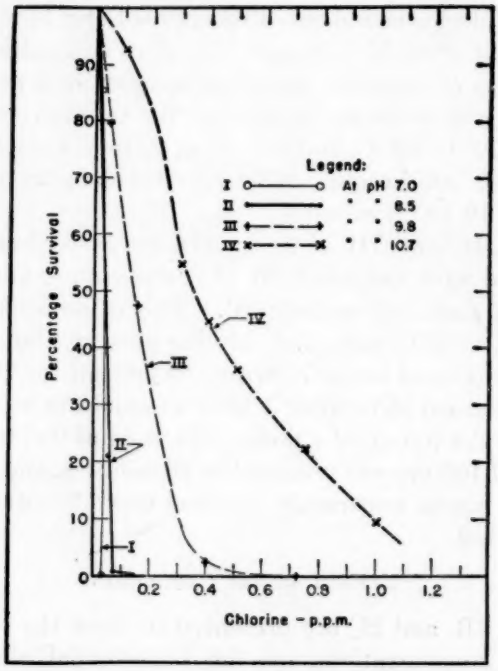

FIGURE 2A.—pH effect on survival of *Esch. coli* exposed to chlorine in various concentrations for 10 minutes at 2°–5° C.

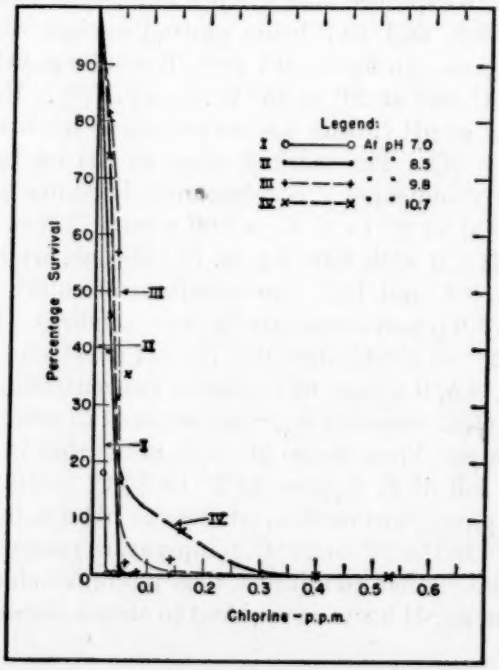

FIGURE 2B.—pH effect on survival of *Esch. coli* exposed to chlorine in various concentrations for 10 minutes at 20°–25° C.

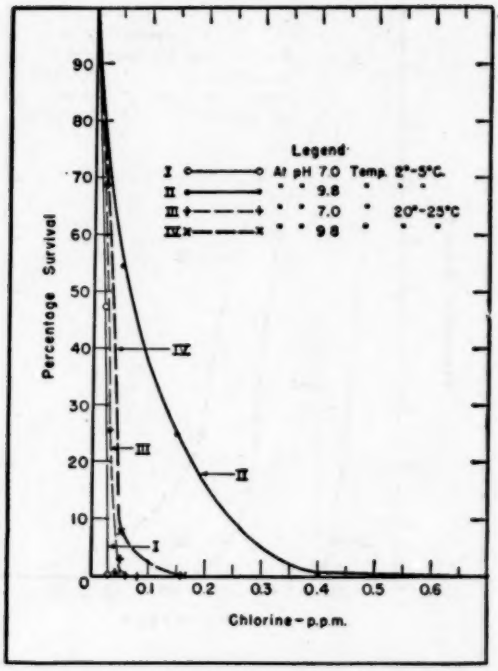

FIGURE 2C.—pH effect on survival of *Eber. typhosa* exposed to chlorine in various concentrations for 10 minutes at two temperatures, 2°–5° C. and 20°–25° C.

INFLUENCE OF TEMPERATURE VARIATION

The influence of variation in temperature on the bactericidal efficiency of chlorine is illustrated in figures 3A, 3B, and 3C. To avoid confusion in the lines on the charts the time variable has been omitted and only the results for the 5-minute exposure time plotted. The *Esch. coli* data have been divided for the same reason, the results obtained at pH 7.0 and 8.5 being presented in figure 3A and at pH 9.8 and 10.7 in figure 3B. At pH 7.0, the influence of temperature on the *Esch. coli* kill was not marked except at a residual of 0.02 p.p.m. With residuals of 0.03 p.p.m. and over the results obtained at each temperature were approximately identical. At pH 8.5, however, a marked difference was observed in the extent of kill with equivalent chlorine residuals at the two temperature ranges. For instance, though a 100-percent kill was produced by 0.07 p.p.m. at 20° to 25° C., 0.14 p.p.m. or more of residual chlorine was required at 2° to 5° C. At both pH 7.0 and 8.5 the rate of kill of *Esch. coli* was slower at the lower temperature.

At pH 9.8 and 10.7, the temperature effect was much more marked throughout the range of chlorine concentrations tried, that is, from 0.02 to 1.0 p.p.m. For example, at pH 9.8 a chlorine residual of 0.3 p.p.m. produced a 100-percent kill of *Esch. coli* at 20° to 25° C. in 5 minutes, whereas 1.0 p.p.m. was required to accomplish the same result

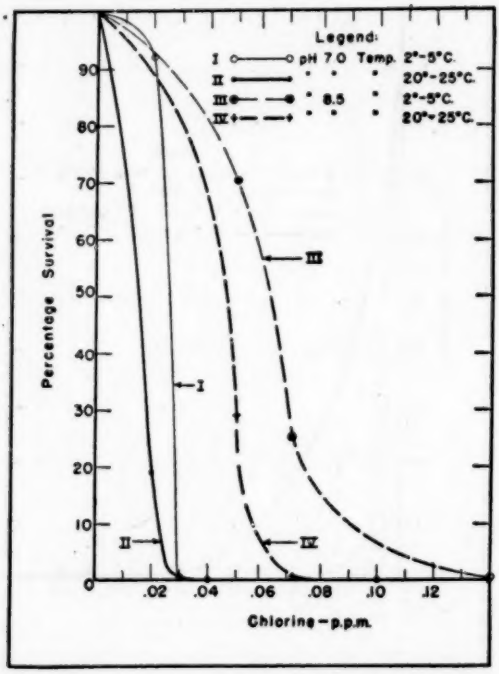
Legend:
I pH 7.0 Temp. 2°-5°C.
II " " " 20°-25°C.
III 8.5 " 2°-5°C.
IV " " " 20°-25°C.
Percentage Survival
Chlorine - p.p.m.
.02 .04 .06 .08 .10 .12
0 10 20 30 40 50 60 70 80 90

FIGURE 3A.—Influence of temperature on the survival of *Esch. coli* when exposed to chlorine in various concentrations for 5 minutes at pH 7.0 and at pH 8.5.

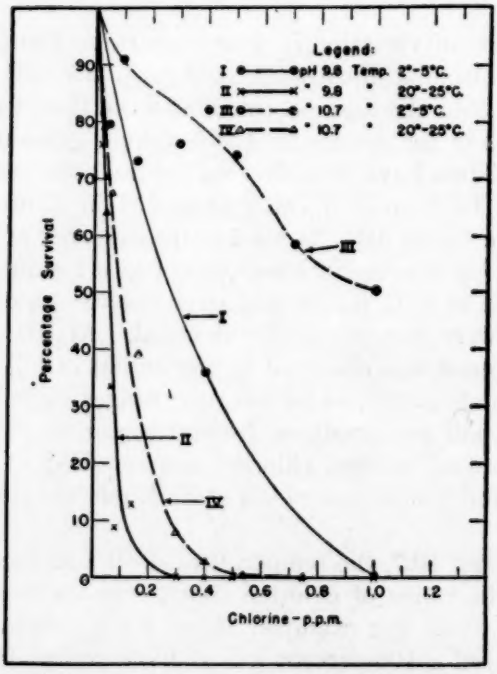

FIGURE 3B.—Influence of temperature on the survival of *Esch. coli* when exposed to chlorine in various concentrations for 5 minutes at pH 9.8 and at pH 10.7.

at 2° to 5° C. Similarly at pH 10.7 about 0.4 p.p.m. produced a 100-percent kill in 10 minutes at 20° to 25° C., but 1.0 p.p.m. at 2° to 5° C. required about 60 minutes to produce a similar result.

In a similar manner, the influence of temperature on the bactericidal efficiency of chlorine for *E. typhosa* at pH 7.0 and 9.8 is shown in figure 3C. At pH 7.0, temperature apparently has but slight influence on the toxicity of chlorine for *E. typhosa* but strange as it may seem the slight effect indicated was in the direction of an increased sensitivity at the lower temperature, just the reverse of the effect on other species

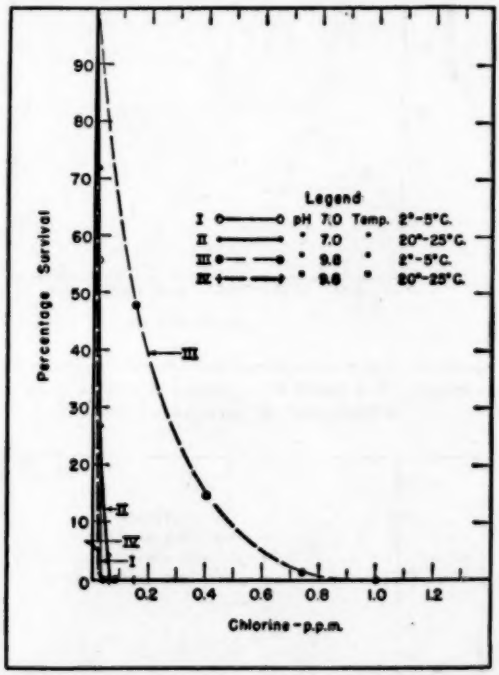

FIGURE 3C.—Influence of temperature on the survival of *Eber. typhosa* when exposed to chlorine in various concentrations for 5 minutes at pH 7.0 and at pH 9.8.

studied. At pH 9.8, however, a 100-percent kill of *E. typhosa* was obtained in 3 minutes at 20° to 25° C. with 0.3 p. p. m. (99.4 percent with 0.16 p. p. m.) of chlorine, whereas at 2° to 5° C. about 1.0 p. p. m. was required to obtain the same result.

VARIATIONS IN GENUS SENSITIVITY

Variations in the sensitivity to chlorine of the different species of the genera studied are shown in figures 4A to 4E, inclusive. In these charts the percentage survival of the various genera is plotted against chlorine residuals. Results obtained after an exposure time of 5 minutes only were used in all cases. This 5-minute period was selected because maximum differences were observed at this interval. With longer times, the differences in sensitivity tended to be reduced mark-

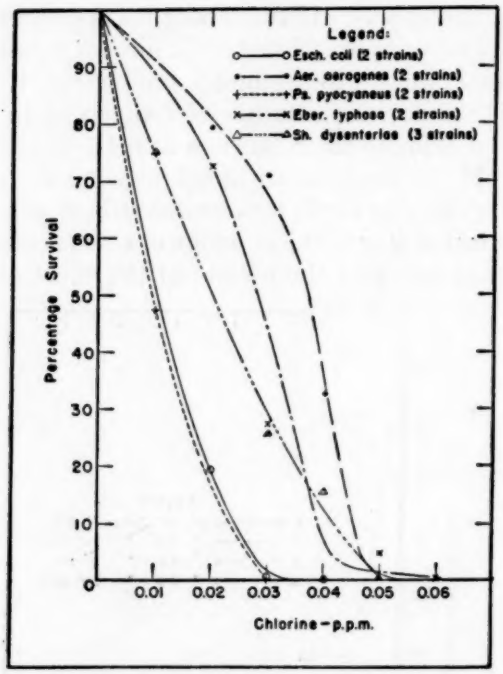

FIGURE 4A.—Relative survival of five species when exposed to chlorine in various concentrations for 5 minutes at 20°–25° C., and at pH 7.0.

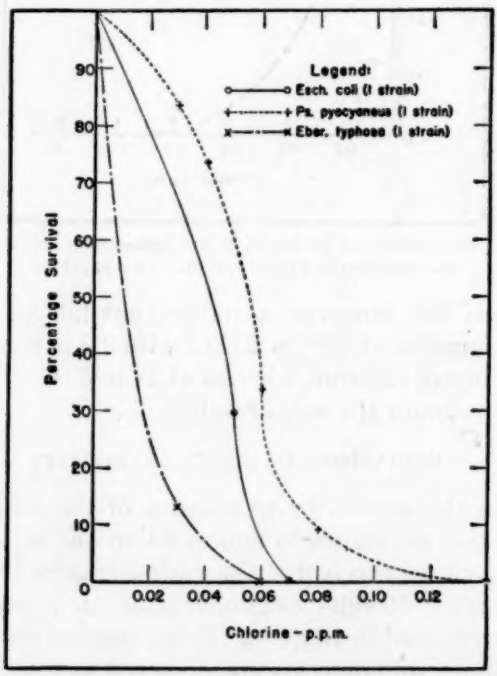

FIGURE 4B.—Relative survival of three species when exposed to chlorine in various concentrations for 5 minutes at 20°–25° C., and at pH 8.5.

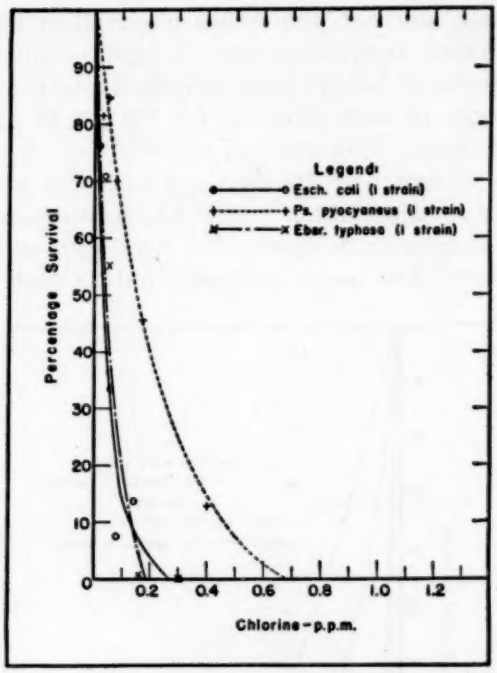

FIGURE 4C.—Relative survival of three species when exposed to chlorine in various concentrations for 5 minutes at 20°–25° C., and at pH 9.8.

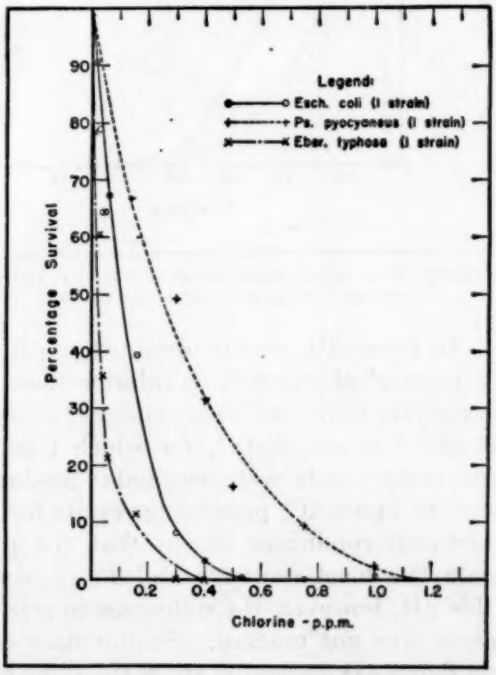

FIGURE 4D.—Relative survival of three species when exposed to chlorine in various concentrations for 5 minutes at 20°–25° C., and at pH 10.7.

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edly. In general, however, the trends observed at the 5-minute exposure period (with two exceptions, *E. typhosa* and *Ps. pyocyanea* which will be discussed below) held throughout the range of the observations. Five genera were tested at pH 7.0 but at pH 8.5, 9.8, and 10.7 only three genera were studied.

In figure 4A, showing results obtained with five genera at pH 7.0 and a temperature range of 20° to 25° C., *A. aerogenes* was the most resistant, with *E. typhosa*, *S. dysenteriae*, *Esch. coli*, and *Ps. pyocyanea* following in order. The latter genus was only slightly more sensitive

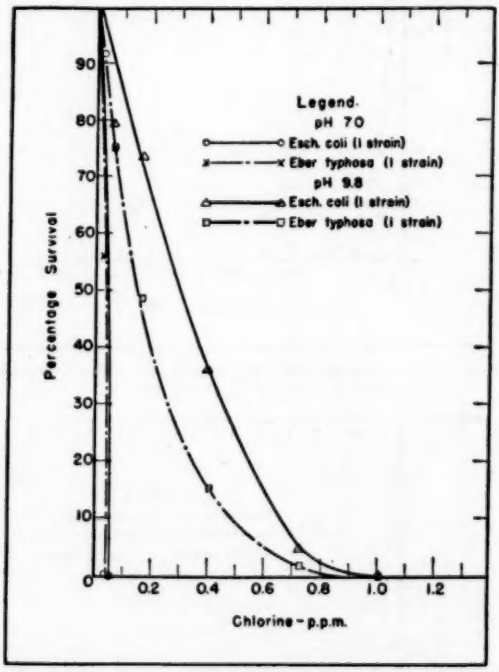

FIGURE 4E.—Relative survival of two species when exposed to chlorine in various concentrations for 5 minutes at 2°–5° C., and at pH 7.0 and pH 9.8.

than *Esch. coli*. In figure 4B, results obtained at pH 8.5 and at 20° to 25° C. after 5 minutes of exposure to chlorine show that *E. typhosa* was the most sensitive, *Esch. coli* next, and *Ps. pyocyanea* the least sensitive of the three genera tested, for which 0.06, 0.1, and 0.15 p. p. m. of chlorine, respectively, were required to produce a 100-percent kill in 5 minutes. In figure 4C, presenting results for the same three genera under identical conditions except that the pH was 9.8, *E. typhosa* was again the most sensitive and *Ps. pyocyanea* the most resistant. At this pH, however, the difference in sensitivity of *Esch. coli* and *E. typhosa* was not marked. Similar data obtained at pH 10.7, as shown in figure 4D, indicated again the same order of relative sensitivity. At this pH, 10.7, and temperature, 20° to 25° C., a 100-percent kill in 5 minutes required for *E. typhosa* about 0.4 p. p. m., for

Esch. coli about 0.8 p.p.m., and for *Ps. pyocyanea* more than 1.0 p. p. m. of chlorine. In figure 4E results obtained after 5 minutes of exposure to chlorine with two genera, *Esch. coli* and *E. typhosa*, at two pH zones, 7.0 and 9.8, and at low temperature, 2° to 5° C., are shown. At pH 7.0, under these conditions, the two genera were about equally sensitive, with *Esch. coli* appearing to be slightly more resistant, though the difference was insignificant. At pH 9.8, however, *Esch. coli* was definitely more resistant to chlorine than *E. typhosa*.

Reference is made now to the exceptions noted for *E. typhosa* and *Ps. pyocyanea*. From the results as shown in tables 1 and 4 and in figure 4A, it is clearly indicated that at pH 7.0 and at 20° to 25° C. the strains of *E. typhosa* tested were slightly more resistant than *Esch. coli* to chlorine at all concentrations tried. It is also noted that for all tests conducted at the higher pH zones, figures 4B to 4D, the *E. typhosa* strains were less resistant to chlorine than *Esch. coli*. This suggests that a variation in sensitivity to chlorine for certain bacterial species may exist at different hydrogen-ion concentrations. This observation was made after the tables and figures for this report had been prepared. To obtain more information on this point additional exploratory tests with *Esch. coli* and *E. typhosa* were made at pH 6.5 and 7.8, with a temperature range of 20° to 25° C. The results obtained from these additional tests tended to confirm the observation concerning a probable shift in sensitivity with pH. At pH 6.5 *E. typhosa* was definitely more resistant to chlorine than *Esch. coli*. At pH 7.8 the same condition prevailed at the lowest concentrations of chlorine tried, 0.02 to 0.03 p.p.m., but at greater concentrations, 0.06 p.p.m. or more, *Esch. coli* became slightly more resistant than *E. typhosa*. Thus it would appear, on the basis of this evidence, that there is a reversal in the relative sensitivity of *E. typhosa* and *Esch. coli* to chlorine somewhere in the pH range of 7.8 to 8.5. A similar indication is noted in the results obtained with *Ps. pyocyanea* strains. At pH 7.0 these strains were the most sensitive to chlorine of all species tested, whereas at pH 8.5, 9.8, and 10.7 they were in all cases the most resistant. A final conclusion on this matter must be held in abeyance, however, until additional tests at other pH zones and with a much larger number of bacterial strains have been made.

TIME REQUIRED TO PRODUCE A 100-PERCENT KILL

Data are presented in table 6 showing the time required to produce a 100-percent kill of the various bacteria studied when exposed to free chlorine in varying concentrations at the four pH zones and two temperature ranges investigated. Certain apparent discrepancies in these results are noted. For instance, with *A. aerogenes* at pH 7.0 and a temperature range of 20° to 25° C. a chlorine concentration of about 0.046 to 0.055 p.p.m. produced a 100-percent kill in 15 minutes in one

experiment, whereas in another experiment 90 minutes were required to produce the same results with about 0.056 to 0.07 p.p.m. of chlorine. A similar inconsistency was observed for *E. typhosa* at pH 7.0 and 20° to 25° C. for chlorine ranges of about 0.036 to 0.045 and 0.046 to 0.055

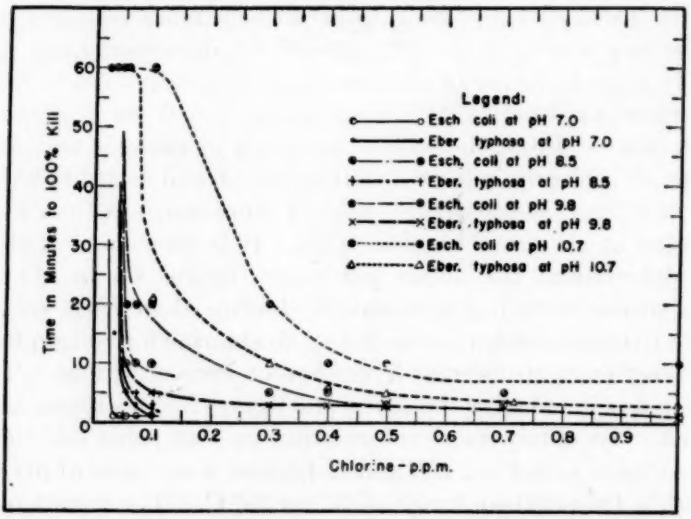
Time in Minutes to 100% Kill
Chlorine - p.p.m.
Legend:
Esch. coli at pH 7.0
Eber. typhosa at pH 7.0
Esch. coli at pH 8.5
Eber. typhosa at pH 8.5
Esch. coli at pH 9.8
Eber. typhosa at pH 9.8
Esch. coli at pH 10.7
Eber. typhosa at pH 10.7

FIGURE 5A.—Minutes required to produce 100-percent kill of *Esch. coli* and *Eber. typhosa* at 20°–25° C. when exposed to chlorine in various concentrations, and at various hydrogen-ion concentrations.

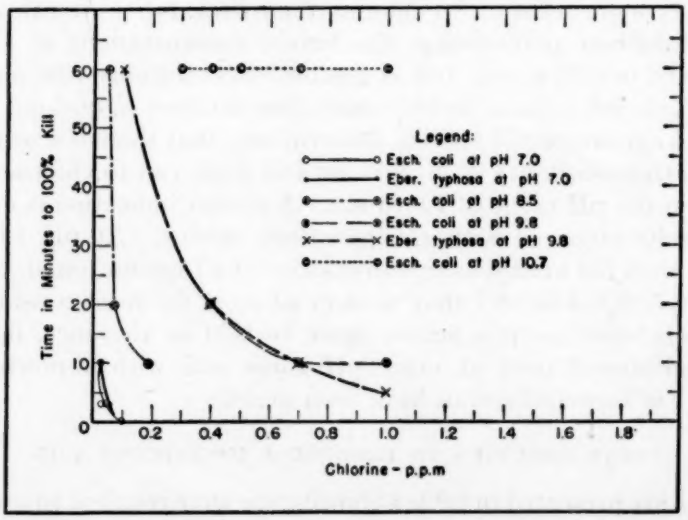
Time in Minutes to 100% Kill
Chlorine - p.p.m
Legend:
Esch. coli at pH 7.0
Eber. typhosa at pH 7.0
Esch. coli at pH 8.5
Esch. coli at pH 9.8
Eber typhosa at pH 9.8
Esch. coli at pH 10.7

FIGURE 5B.—Minutes required to produce 100-percent kill of *Esch. coli* and *Eber. typhosa* at 2°–5° C. when exposed to chlorine in various concentrations, and at various hydrogen-ion concentrations.

p.p.m. No explanation for these inconsistencies is advanced other than to suggest that this is the type of normal variation which must be expected in repeating tests with biological forms exposed to a considerable number of variables. Such results tend to emphasize the neces-

sity of always allowing a reasonable factor of safety in the required concentrations of bactericidal agents.

To compare the time required with various chlorine concentrations in order to produce a 100-percent kill of *Esch. coli* and *E. typhosa* in the four pH zones studied, the data for these two genera have been plotted in figures 5A and 5B for results obtained at 20° to 25° C. and 2° to 5° C., respectively. Similar comparison may be made with the other genera studied by plotting the data given in table 6.

It is noted from figure 5A that at pH 7.0 and at a temperature range of 20° to 25° C. *Esch. coli* was apparently more sensitive to chlorine than *E. typhosa* until a chlorine concentration of about 0.1 p. p. m. or more was reached. At pH 8.5, 9.8, and 10.7 in the same temperature range, however, *E. typhosa* was found to be equally or more sensitive to chlorine than *Esch. coli* This apparent reversal of sensitivity to chlorine with changing pH has been reviewed in the discussion of the data of the series 4 figures. Although factual information to support the theory is not available, it might be suggested that the capsular substance of the more heavily encapsulated typhosa organisms may become less permeable to chlorine in the lower pH range and that under such conditions the more sensitive cell is not penetrated as readily until higher concentrations of chlorine are used.

It is of interest to observe also that to produce a 100-percent kill of *Esch. coli* at 20° to 25° C. with a chlorine concentration of about 0.046 to 0.055 p. p. m. it required 1 minute at pH 7.0, and at pH 8.5, 9.8, and 10.7 between 20 and 60 minutes of exposure, or at least twenty times the exposure time required under the same conditions at pH 7.0. With a higher concentration of chlorine, 0.1 to 0.29 p. p. m. and also 20° to 25° C. a 100-percent kill of *Esch. coli* at pH 7.0, 8.5, 9.8, and 10.7 required an exposure time of 1,[2] 10, 20, and 60[2] minutes, respectively. Considering the results for *E. typhosa*, a similar pH effect is noted. With a chlorine concentration of 0.1 to 0.29 p.p.m., exposure times of 1, 3, 5, and 20 minutes, respectively, were required to obtain a 100-percent kill at 20° to 25° C. with pH values of 7.0, 8.5, 9.8, and 10.7. Thus under the same conditions of chlorine concentration (0.1 to 0.29 p. p. m.) and temperature range (20° to 25° C.) at the four pH zones of 7.0, 8.5, 9.8, and 10.7, exposure times of 1, 10, 20, and 60 minutes, and 1, 3, 5, and 20 minutes, respectively, were required to produce a 100-percent kill of *Esch. coli* and *E. typhosa*. Similar comparisons of the increasing chlorine concentrations required, with decreasing hydrogen-ion concentrations, to produce a 100-percent kill during the same interval of time may be read from figure 5A and table 6. For instance, it is noted that from ten to thirty times as

[2] In this connection it should be observed that actually a 100-percent kill was obtained probably in less than 1 minute (the minimum observation interval) at pH 7.0 as 0.036 to 0.045 p. p. m. (about one-third the chlorine concentration used here) also produced a 100-percent kill in 1 minute. Similarly at pH 10.7 the time of the 100-percent kill may have been somewhat less than 60 minutes as examinations were not made between the 20- and 60-minute periods.

much chlorine was required at pH 9.8 to obtain a 100-percent kill of *Esch. coli* and *E. typhosa* in the same time interval as was required at pH 7.0.

In figure 5B, similar results are presented for *Esch. coli* and *E. typhosa* with chlorine in various concentrations in the same four pH zones but at a temperature range of 2° to 5° C. With this lower temperature, at pH 7.0, 0.1 p. p. m. of chlorine was required to produce a 100-percent kill of *Esch. coli* in 1 minute, whereas slightly less, 0.08 p. p. m., was required for *E. typhosa*. At pH 9.8 and 10.7, but otherwise under the same conditions, 100-percent kills were not obtained in 1 minute with 1.0 p. p. m. of chlorine with either species, 10 minutes being required with this concentration at pH 9.8 and 60 minutes at pH 10.7 for *Esch. coli*, whereas *E. typhosa* were all killed by this concentration of chlorine in 5 minutes at pH 9.8.

Similar comparison of the influence of temperature variation (table 6) indicates that in the lower temperature range the period of exposure required to effect a 100-percent kill of *Esch. coli* was two to twelve times as long as in the higher range of 20° to 25° C., or the concentration of chlorine required for a 100-percent kill in the same period of exposure was two to ten times greater in the lower than in the higher temperature range.

MAXIMUM AND MINIMUM PERCENTAGE OF SURVIVAL

The value of the results presented naturally depends on (1) the care and the technique used in obtaining them, and (2) the inherent differences occurring between individual observations, particularly as induced by biological variations in resistance. Consideration of the care and technique used has been covered fully in the discussion of methods. Although a critical statistical analysis of the results presented is not within the province of this report, some conception of the variations observed may be realized from a review of the maximum and minimum percentages of survival obtained. A tabulation of such percentages has been prepared and studied, for each time interval and each chlorine concentration, under all of the conditions investigated. In general, as would be anticipated, the greatest differences between the maximum and the minimum results were encountered when the extent of bacterial kill was the least; that is, when the amounts of chlorine used were the smallest and when other conditions reduced the bactericidal properties of chlorine.

To illustrate these variations, the maximum and minimum percentages of survival after 5 minutes of exposure at a temperature range of 2° to 5° C. are shown for *Esch. coli* and *E. typhosa* in figure 6A as obtained at pH 7.0 and in figure 6B as obtained at pH 9.8. It is noted that the greatest differences are shown with the lowest chlorine concentrations and that in this range greater differences were observed with *E. typhosa* than with *Esch. coli;* also that with increased chlorine

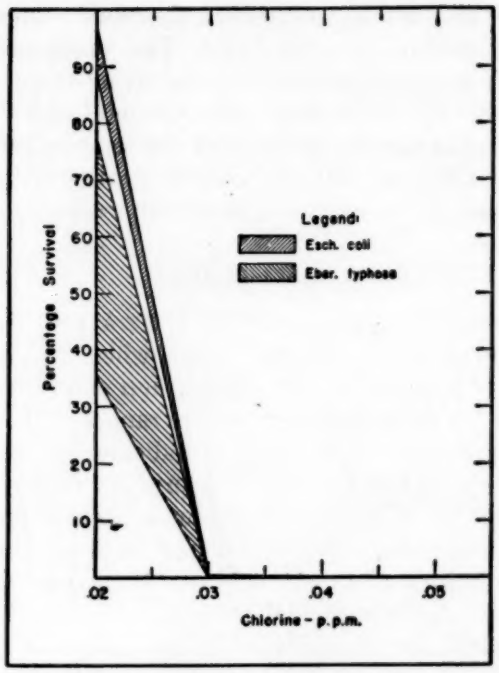

FIGURE 6A.—Maximum and minimum percentage survival of two species in various chlorine concentration ranges after 5 minutes' exposure at pH 7.0 and 2°–5° C.

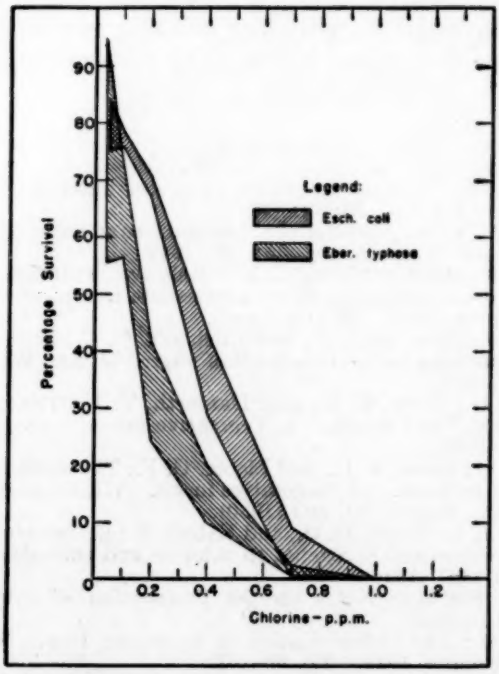

FIGURE 6B.—Maximum and minimum percentage survival of two species in various chlorine concentration ranges after 5 minutes' exposure at pH 9.8 and 2°–5° C.

concentrations the differences between the maximum and minimum percentages of survival decrease and that under such conditions differences for *E. typhosa* tended to become equal to or less than those for *Esch. coli*. Similar differences, but in general of lesser magnitude, were observed in the results obtained in the temperature range of 20° to 25° C. It is believed that the variations observed are within the range which would be expected and that they warrant fully the limited deductions made.

CONCLUSIONS

Observations on the relative survival of *Esch. coli*, *A. aerogenes*, *Ps. pyocyanea*, *E. typhosa*, and *S. dysenteriae*, when exposed to free chlorine in waters of four different hydrogen-ion concentrations, pH 7.0, 8.5, 9.8, and 10.7, and at two temperature ranges, 2° to 5° C., and 20° to 25° C., are presented. The results indicate: (1) the time of exposure of bacteria to free chlorine is a primary factor governing the extent of the bacterial kill; (2) hydrogen-ion concentration has a marked effect on the bactericidal efficiency of free chlorine, the killing power diminishing with increasing pH values; (3) increase in temperature tends to increase the bactericidal properties of free chlorine. When the effect of a lowered temperature is superimposed on a high pH, the reduction in the bactericidal efficiency of free chlorine is very marked; (4) at pH zones of 8.5, 9.8, and 10.7 strains of *E. typhosa* tested were more sensitive to chlorine than *Esch. coli* or *Ps. pyocyanea*. At pH 6.5, 7.0, and 7.8, with free chlorine concentrations of 0.03 p. p. m. or less, *E. typhosa* appeared to be slightly more resistant than *Esch. coli* or *Ps. pyocyanea*.

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COURT DECISIONS ON PUBLIC HEALTH

City tourist camp ordinance held to conflict with State trailer park law.—(Michigan Supreme Court; *Richards et al.* v. *City of Pontiac et al.*, 9 N.W.2d 885; decided June 7, 1943.) In March 1941 the city of Pontiac adopted an ordinance relating to tourist camps. This ordinance, among other things, required a license, the fee for which was $10 per year for each unit capacity of the camp, and provided that "Any occupied camp and/or trailer or house tent may be located at any regularly licensed tourist camp * * * for a period not to exceed three months in any 12-month period." In 1939 the Michigan legislature enacted a statute regulating trailers and trailer camps within townships, and in 1941 this law was amended to provide for the regulation of house-trailer camps in all parts of the State.

The plaintiffs owned a trailer camp in Pontiac, and in September 1941 brought suit to enjoin the city from interfering with their camp under the provisions of the tourist camp ordinance. The director of public health of the city, by cross-bill, sought to have the plaintiffs restrained from using their property as a trailer camp and from renting trailers and substandard houses. The plaintiffs claimed that the ordinance conflicted with the above-mentioned statute and the State supreme court sustained their contention. Concerning the law, the court said that it was enacted because of a shortage of habitable houses for defense workers and was designed to regulate the trailer type of housing and intended to apply to trailers as permanent, as well as temporary, dwellings. It provided for a monthly license fee of $1.50 for each occupied trailer coach occupying space and permitted a trailer coach to remain in a given location for an indefinite length of time. Its intent and purpose, according to the court, was to take over the entire field of regulation and supervision of trailer parks in the State. After citing a prior case in which it was stated to be the rule that, in the absence of specific statutory or charter power in the municipality, the provisions of an ordinance which contravened a State law were void, the supreme court pointed out that the ordinance conflicted with the statute, and was therefore void, in the following respects: The State law permitted unlimited parking of trailers while the ordinance fixed a time limit for such parking; the ordinance required an annual license fee of $10 for each unit capacity of the camp while the law provided for a different license fee. Concerning the latter aspect of the conflict, the court said that "The State having entered the field of licensing tourist camps, any provision for additional fees, imposed by an ordinance for such licensing, is void."

With reference to the State housing law, the court took judicial notice of the fact that when this law was enacted in 1917 the problems

arising out of trailer camps were not a matter requiring legislation and that it was not intended that the act would apply to the construction of trailers and trailer camps. Also, the legislature did not intend to repeal the housing law by enacting the trailer-park law.

Answering the contention that a city zoning ordinance, as amended, required elimination of the plaintiffs' trailer camp from its present location, the court said that the plaintiffs, having purchased the property, expended money thereon, and operated a trailer camp prior to the existence of either of the zoning ordinances, had a vested right to operate such trailer camp in accordance with the State statute or as such statute might be amended.

The trial court's decree, granting a permanent injunction against interference with the plaintiffs by virtue of any authority contained in the ordinance, was affirmed.

Uniform narcotic drug act—earlier law impliedly repealed by—marihuana included under.—(Nevada Supreme Court; *State* v. *Economy*, 130 P.2d 264; decided October 20, 1942.) In this case one of the conclusions reached by the Supreme Court of Nevada was that the State Narcotic Drug Act of 1923, as amended, was impliedly repealed by the Uniform Narcotic Drug Act enacted by the State legislature in 1937. While the later act contained no specific repealing clause but provided in general terms that inconsistent acts or parts of acts were repealed, the court pointed out that it was in effect a revision of the earlier law and was a complete system for regulating the possession, use, sale, distribution, or administration of narcotic drugs.

Another point decided by the court was that, while the 1937 uniform law did not name marihuana as a narcotic drug, the definition of cannabis in such law embraced marihuana. The statute denominated cannabis as a narcotic drug and defined it as including "the following substances under whatever names they may be designated: (*a*) the dried flowering or fruiting tops of the pistillate plant Cannabis sativa L., from which the resin has not been extracted, (*b*) the resin extracted from such tops, and (*c*) every compound, manufacture, salt, derivative, mixture, or preparation of such resin, or of such tops from which the resin has not been extracted." Under all authorities, said the court, this definition embraces marihuana, which is a product of cannabis.

Public health law construed.—(New York Court of Appeals; *Fisher et al., Common Council*, v. *Kelly, Mayor*, 44 N.E.2d 413; decided October 16, 1942.) A local law of the city of Buffalo substituted a commissioner of health for a board of health. In a controversy concerning the validity of this local law the Court of Appeals of New York had occasion to construe the first sentence of section 20 of the State public health law, which provided: "There shall continue to be local boards of health and health officers in the several cities, villages

and towns of the State except as hereinafter provided." The court said that, though in its opinion this sentence was intended to apply to all cities of the State, it should not be construed as a requirement that in every city, village, and town there should be both a local board of health and a health officer. The court's view was that, reasonably construed, the sentence could mean only that local boards of health and local health officers were not abolished by the statute and that in each city, village, or town the duties conferred upon or required of local boards of health by the laws of the State should continue to be performed by a local health officer or board. So construed, the local law of the city of Buffalo was held not to be in conflict with such sentence. The court pointed out, however, that in other portions of section 20 and in section 21 of the public health law a form of organization was provided for certain cities and stated that "There is here no room for construction concerning the form of organization required in those cities which are included within the scope of these statutory provisions." The court held that such provisions had no application to the city of Buffalo.

DEATHS DURING WEEK ENDED DECEMBER 4, 1943

[From the Weekly Mortality Index, issued by the Bureau of the Census, Department of Commerce]

	Week ended Dec. 4, 1943	Corresponding week, 1942
Data for 87 large cities of the United States:		
Total deaths	9,565	9,490
Average for 3 prior years	8,742	
Total deaths, first 48 weeks of year	422,607	395,054
Deaths under 1 year of age	652	674
Average for 3 prior years	570	
Deaths under 1 year of age, 48 weeks of year	30,218	27,379
Data from industrial insurance companies:		
Policies in force	66,088,599	65,292,503
Number of death claims	12,132	12,811
Death claims per 1,000 policies in force, annual rate	9.6	10.2
Death claims per 1,000 policies 48 weeks of year, annual rate	9.6	9.1

PREVALENCE OF DISEASE

No health department, State or local, can effectively prevent or control disease without knowledge of when, where, and under what conditions cases are occurring

UNITED STATES

REPORTS FROM STATES FOR WEEK ENDED DECEMBER 11, 1943

Summary

A total of 23,746 cases of influenza was reported, or more than five times the preceding week's total of 4,489, and nearly nine times the median of 2,742 for the corresponding week of the past 5 years. The infection is reported to be of a mild type. Excessive incidence is noted in certain States of each geographic area except the New England, Middle Atlantic, and Pacific. Of the current total, 16,654 cases, or 70 percent, were reported in 5 States, as follows (last week's figures in parentheses): Iowa 2,337 (0), North Dakota 4,331 (23), Virginia 1,649 (651), Kentucky 5,416 (3), and Texas 2,921 (1,298). Preliminary reports from certain selected cities well distributed geographically show for the weeks ended December 4 and December 11 a slight excess mortality from influenza and pneumonia combined, as compared with figures for 1942 and averages for the past 3 years.

A slight increase in the incidence of meningococcus meningitis was recorded for the week. A total of 287 cases was reported, as compared with 274 for the preceding week and a 5-year median of 34. States reporting more than 8 cases (last week's figures in parentheses) are as follows: *Increases*—Massachusetts 16 (13), New York 41 (31), New Jersey 11 (10), Pennsylvania 34 (33), Ohio 16 (9), Illinois 22 (14), Missouri 12 (5), and California 26 (25); *decreases*—Michigan 11 (23). The cumulative total for the fourth quarter of the year to date is 2,290, as compared with 716 for the same period last year and a 5-year median of 326.

A total of 96 cases of poliomyelitis was reported, as compared with 141 for the preceding week and a 5-year median of 91. No State reported more than 14 cases.

Current figures for measles and scarlet fever are above the corresponding 5-year medians, while those for diphtheria, smallpox, typhoid fever, and whooping cough are below. The cumulative totals for 49 weeks of the year for measles and whooping cough are above the medians, while those for diphtheria, scarlet fever, smallpox, and typhoid fever are below.

Deaths recorded in 90 large cities for the week totaled 10,373, as compared with 9,845 last week and a 3-year (1940–42) average of 8,868. The cumulative total for the year to date is 445,120, as compared with 415,304 for the same period of 1942.

Telegraphic morbidity reports from State health officers for the week ended December 11, 1943, and comparison with corresponding week of 1942 and 5-year median

In these tables a zero indicates a definite report, while leaders imply that, although none was reported, cases may have occurred.

Division and State	Diphtheria			Influenza			Measles			Meningitis, meningococcus		
	Week ended—		Median 1938–42	Week ended—		Median 1938–42	Week ended—		Median 1938–42	Week ended—		Median 1938–42
	Dec. 11, 1943	Dec. 12, 1942		Dec. 11, 1943	Dec. 12, 1942		Dec. 11, 1943	Dec. 12, 1942		Dec. 11, 1943	Dec. 12, 1942	
NEW ENGLAND												
Maine	3	1	1	22	-------	1	98	7	40	0	6	0
New Hampshire	0	1	0	-------	-------	-------	8	58	4	0	0	0
Vermont	0	0	0	-------	-------	-------	34	109	23	0	0	0
Massachusetts	9	2	3	-------	-------	-------	325	539	236	16	6	2
Rhode Island	0	0	1	1	1	-------	67	20	2	4	3	0
Connecticut	2	0	1	98	2	2	8	235	59	5	4	1
MIDDLE ATLANTIC												
New York	16	22	16	70	[1] 16	[1] 12	600	430	509	41	11	3
New Jersey	4	3	10	50	10	8	405	25	17	11	5	1
Pennsylvania	11	11	21	13	5	-------	410	747	495	34	10	3
EAST NORTH CENTRAL												
Ohio	14	11	19	4	17	14	2,035	36	36	16	3	1
Indiana	13	4	17	286	7	9	80	38	17	3	0	0
Illinois	5	10	34	447	9	9	174	69	28	22	3	1
Michigan [2]	9	7	7	63	2	2	673	38	173	11	0	0
Wisconsin	1	1	1	130	34	20	482	140	140	8	2	1
WEST NORTH CENTRAL												
Minnesota	9	5	5	396	1	2	437	5	33	1	0	0
Iowa	1	4	4	2,337	-------	3	41	40	40	0	0	0
Missouri	6	5	9	137	1	2	22	6	6	12	1	0
North Dakota	2	1	2	4,331	1	10	380	0	17	0	0	0
South Dakota	1	0	4	-------	-------	-------	71	55	1	0	1	0
Nebraska	2	4	2	-------	21	-------	6	83	4	0	0	0
Kansas	11	0	4	197	18	11	11	21	32	3	0	0
SOUTH ATLANTIC												
Delaware	0	0	0	-------	-------	-------	18	1	2	1	0	0
Maryland [2]	5	2	7	62	8	8	36	4	6	6	4	2
District of Columbia	0	2	2	245	7	2	28	3	1	1	0	0
Virginia	11	21	40	1,649	371	176	550	17	33	8	10	0
West Virginia	5	6	12	629	20	16	60	2	11	4	2	2
North Carolina	28	18	70	3	2	6	166	2	139	5	1	1
South Carolina	5	15	15	755	517	425	45	3	6	3	0	0
Georgia	7	5	19	676	116	116	55	3	27	3	1	0
Florida	4	7	8	16	1	6	23	0	2	1	2	0
EAST SOUTH CENTRAL												
Kentucky	3	8	16	5,416	3	6	6	22	22	6	0	0
Tennessee	9	8	13	285	40	30	20	7	21	3	0	1
Alabama	11	12	27	306	80	80	163	2	14	2	3	1
Mississippi [2]	9	7	12	-------	-------	-------	-------	-------	-------	0	0	1
WEST SOUTH CENTRAL												
Arkansas	9	15	18	427	87	99	23	22	18	1	0	0
Louisiana	6	7	9	84	13	12	1	3	3	2	0	1
Oklahoma	3	9	17	201	185	125	11	10	6	3	1	1
Texas	37	42	55	2,921	732	443	78	13	43	8	2	1
MOUNTAIN												
Montana	0	0	2	34	-------	10	103	95	52	1	1	0
Idaho	0	4	0	2	-------	-------	1	8	8	1	0	0
Wyoming	1	0	1	11	50	8	19	10	3	1	0	0
Colorado	3	10	11	322	46	46	165	12	17	1	2	1
New Mexico	1	2	3	18	-------	-------	0	2	5	0	0	0
Arizona	9	1	1	950	110	127	12	4	4	1	0	0
Utah [2]	0	1	1	56	-------	28	12	658	29	2	1	0
Nevada	0	0	0	-------	-------	-------	1	11	0	1	0	0
PACIFIC												
Washington	7	5	1	2	-------	-------	45	383	248	1	2	0
Oregon	3	9	1	25	16	23	50	221	34	8	10	2
California	22	23	26	69	55	55	105	66	134	26	6	1
Total	317	331	569	23,746	2,604	2,742	8,161	4,285	4,063	287	103	34
49 weeks	12,960	14,643	15,659	126,643	101,023	109,793	580,588	491,288	491,288	16,817	3,387	1,915

See footnotes at end of table.

Telegraphic morbidity reports from State health officers for the week ended December 11, 1943, and comparison with corresponding week of 1942 and 5-year median—Con.

Division and State	Poliomyelitis			Scarlet fever			Smallpox			Typhoid and paratyphoid fever [2]		
	Week ended—		Median 1938–42	Week ended—		Median 1938–42	Week ended—		Median 1938–42	Week ended—		Median 1938–42
	Dec. 11, 1943	Dec. 12, 1942		Dec. 11, 1943	Dec. 12, 1942		Dec. 11, 1943	Dec. 12, 1942		Dec. 11, 1943	Dec. 12, 1942	
NEW ENGLAND												
Maine	0	1	1	21	25	18	0	0	0	0	1	2
New Hampshire	0	0	0	6	9	3	0	0	0	0	1	0
Vermont	0	0	0	7	5	5	0	0	0	0	0	0
Massachusetts	4	0	0	244	293	140	0	0	0	2	2	2
Rhode Island	0	0	0	6	6	7	0	0	0	0	0	0
Connecticut	0	0	0	47	37	39	0	0	0	1	0	1
MIDDLE ATLANTIC												
New York	14	3	3	353	278	273	0	0	0	5	6	6
New Jersey	0	0	2	99	59	95	0	0	0	1	2	2
Pennsylvania	0	5	2	213	225	234	0	0	0	6	0	5
EAST NORTH CENTRAL												
Ohio	1	2	2	278	330	330	0	0	0	0	5	6
Indiana	0	1	1	57	55	114	0	6	6	1	0	1
Illinois	4	0	1	202	161	294	1	1	1	1	2	7
Michigan [3]	4	3	2	154	111	154	0	0	1	1	1	1
Wisconsin	1	1	1	148	178	146	0	1	2	0	1	1
WEST NORTH CENTRAL												
Minnesota	0	0	2	110	88	89	0	0	16	0	2	0
Iowa	0	2	2	67	68	62	1	0	4	0	0	0
Missouri	1	0	0	64	66	66	0	0	3	1	8	2
North Dakota	1	0	1	17	5	21	0	0	0	0	0	0
South Dakota	0	0	0	33	33	33	0	0	0	1	0	0
Nebraska	0	0	0	31	18	20	1	2	0	0	0	0
Kansas	3	3	1	93	67	88	4	0	0	0	0	1
SOUTH ATLANTIC												
Delaware	0	0	0	7	5	12	0	0	0	0	1	1
Maryland [3]	0	1	1	88	54	51	0	0	0	2	2	4
District of Columbia	0	0	0	23	14	14	0	0	0	0	0	0
Virginia	1	0	1	40	45	52	0	0	0	2	0	4
West Virginia	1	0	0	50	47	49	0	0	0	2	1	5
North Carolina	1	0	1	107	81	99	0	0	0	1	2	2
South Carolina	0	1	1	8	21	20	1	0	0	3	0	3
Georgia	1	0	1	15	34	34	0	0	0	0	4	4
Florida	1	0	0	23	7	7	0	0	0	1	0	2
EAST SOUTH CENTRAL												
Kentucky	2	0	2	75	39	89	0	0	0	1	2	3
Tennessee	0	1	1	78	74	58	0	0	0	1	8	7
Alabama	0	0	1	20	19	35	0	0	0	1	0	0
Mississippi [3]	0	0	1	9	20	20	0	1	0	3	0	1
WEST SOUTH CENTRAL												
Arkansas	1	3	1	6	6	13	0	0	1	0	3	3
Louisiana	1	0	1	7	8	14	0	0	0	0	3	5
Oklahoma	5	0	1	26	26	24	0	0	1	5	1	2
Texas	10	22	2	63	39	56	1	1	1	10	10	10
MOUNTAIN												
Montana	1	0	0	32	10	16	1	0	1	0	0	0
Idaho	0	0	0	52	1	10	0	1	0	0	0	0
Wyoming	1	0	0	3	3	7	0	0	0	0	0	0
Colorado	4	2	1	36	47	45	0	0	0	0	2	0
New Mexico	1	0	0	1	9	17	0	0	0	4	2	3
Arizona	0	1	0	18	2	4	2	0	0	0	3	0
Utah [3]	2	1	1	88	53	22	0	0	0	1	0	0
Nevada	0	0	0	2	0	0	0	0	0	1	0	0
PACIFIC												
Washington	7	0	1	152	23	29	0	0	0	0	0	1
Oregon	9	0	1	99	19	20	0	0	2	0	0	1
California	14	13	5	179	144	144	0	0	1	26	4	5
Total	96	66	91	3,557	2,967	3,091	12	13	50	84	79	140
49 weeks	12,230	4,047	7,125	131,727	118,838	146,519	713	750	2,292	5,306	6,531	9,286

See footnotes at end of table.

Telegraphic morbidity reports from State health officers for the week ended December 11, 1943, and comparison with corresponding week of 1942 and 5-year median—Con.

Division and State	Whooping cough			Week ended Dec. 11, 1943								
	Week ended—		Median 1938–42	Anthrax	Dysentery			Encephalitis, infectious	Leprosy	Rocky Mt. spotted fever	Tularemia	Typhus fever
	Dec. 11, 1943	Dec. 12, 1942			Amebic	Bacillary	Unspecified					
NEW ENGLAND												
Maine	10	124	66	0	0	0	0	0	0	0	0	0
New Hampshire	0	8	7	0	0	0	0	0	0	0	0	0
Vermont	30	51	51	0	0	0	0	0	0	0	0	0
Massachusetts	91	305	218	0	0	0	3	1	0	0	0	0
Rhode Island	24	48	36	0	0	0	0	0	0	0	0	0
Connecticut	22	84	84	0	0	1	0	0	0	0	0	0
MIDDLE ATLANTIC												
New York	345	450	494	1	2	12	0	3	0	0	0	0
New Jersey	62	212	212	0	0	0	0	0	0	0	0	0
Pennsylvania	96	347	347	0	2	0	0	2	0	0	1	0
EAST NORTH CENTRAL												
Ohio	127	152	152	0	0	0	0	0	0	0	0	0
Indiana	20	16	17	0	0	0	0	0	0	0	1	0
Illinois	101	176	176	0	0	1	0	2	0	0	4	0
Michigan [1]	204	321	321	0	7	6	0	2	0	0	0	0
Wisconsin	135	216	216	0	0	0	0	0	0	0	0	0
WEST NORTH CENTRAL												
Minnesota	45	42	52	0	6	0	0	0	0	0	0	0
Iowa	23	33	27	0	0	0	0	0	0	0	0	0
Missouri	19	8	14	0	0	0	0	0	0	0	0	0
North Dakota	20	20	13	0	0	0	0	0	0	0	0	0
South Dakota	0	2	2	0	0	0	0	0	0	0	0	0
Nebraska	7	1	7	0	0	0	0	0	0	0	0	0
Kansas	37	27	27	0	0	0	0	0	0	0	1	0
SOUTH ATLANTIC												
Delaware	0	6	13	0	0	0	0	0	0	0	0	0
Maryland [2]	37	126	55	0	0	0	2	0	0	0	5	0
District of Columbia	6	17	17	0	0	0	0	0	0	0	0	0
Virginia	104	29	40	0	1	0	39	0	0	0	1	0
West Virginia	67	23	23	0	0	0	0	0	0	0	0	0
North Carolina	208	33	142	0	0	0	0	0	0	0	0	[4]9
South Carolina	48	32	32	0	0	2	0	0	0	0	0	7
Georgia	25	9	14	0	2	0	0	0	0	0	0	34
Florida	31	3	9	0	0	1	0	1	0	0	0	2
EAST SOUTH CENTRAL												
Kentucky	86	15	45	0	0	1	0	0	0	0	1	0
Tennessee	229	42	42	0	0	0	4	0	0	0	0	0
Alabama	2	5	21	0	0	0	0	0	0	0	0	10
Mississippi [3]				0	0	0	0	0	0	0	0	3
WEST SOUTH CENTRAL												
Arkansas	0	20	19	0	0	2	0	0	0	0	1	1
Louisiana	2	4	9	0	0	10	0	0	0	0	1	4
Oklahoma	4	11	11	0	0	0	0	0	0	0	0	0
Texas	138	161	119	0	55	685	0	2	0	0	0	47
MOUNTAIN												
Montana	6	33	33	0	0	0	0	0	0	0	0	0
Idaho	3	0	0	0	0	0	0	0	0	0	0	0
Wyoming	2	2	4	0	0	0	0	0	0	0	1	0
Colorado	31	14	21	0	1	0	0	0	0	0	0	0
New Mexico	0	16	31	0	1	0	0	0	0	0	0	0
Arizona	14	32	11	0	0	0	59	0	0	0	0	0
Utah [3]	26	17	24	0	0	0	0	0	0	0	0	0
Nevada	0	4	4	0	0	0	0	0	0	0	0	0
PACIFIC												
Washington	61	22	26	0	0	0	0	0	0	0	0	0
Oregon	26	5	23	0	0	0	0	0	0	0	0	0
California	101	248	192	0	2	1	0	0	1	0	1	0
Total	2,675	3,572	4,126	1	79	722	107	13	1	0	18	117
49 weeks	171,855	169,469	169,469	63	2,050	17,099	4,230	660	29	435	746	[4]4,304
49 weeks, 1942				76	1,133	11,763	6,299	542	44	451	831	3,509

[1] New York City only.
[2] Including paratyphoid fever cases reported separately as follows: Massachusetts, 1; Florida, 1; South Carolina, 2; Texas, 4.
[3] Period ended earlier than Saturday.
[4] Later information shows 6 cases of typhus fever for North Carolina for the week ended Nov. 20, 1943, instead of 7 as previously reported.

WEEKLY REPORTS FROM CITIES

City reports for week ended November 27, 1943

This table lists the reports from 85 cities of more than 10,000 population distributed throughout the United States, and represents a cross section of the current urban incidence of the diseases included in the table.

	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
NEW ENGLAND												
Maine:												
Portland	1	0	-----	0	3	0	2	0	4	0	0	1
New Hampshire:												
Concord	0	0	-----	0	0	0	1	0	2	0	0	0
Vermont:												
Barre	0	0	-----	0	0	0	0	0	0	0	0	0
Massachusetts:												
Boston	2	0	-----	1	4	0	7	0	37	0	0	28
Fall River	0	0	-----	0	0	1	1	1	4	0	0	7
Springfield	0	0	-----	0	4	1	0	0	8	0	0	0
Worcester	0	0	-----	0	1	0	6	0	23	0	0	8
Rhode Island:												
Providence	0	0	-----	0	61	1	2	0	3	0	0	24
Connecticut:												
Bridgeport	1	0	-----	0	0	2	0	0	9	0	0	4
Hartford	0	0	-----	0	1	0	3	1	7	0	0	3
New Haven	0	0	-----	0	1	0	0	0	1	0	0	1
MIDDLE ATLANTIC												
New York:												
Buffalo	0	0	-----	1	1	0	5	0	4	0	0	6
New York	13	1	3	1	199	18	44	3	115	0	4	52
Rochester	0	0	-----	0	1	1	8	0	3	0	0	13
Syracuse	0	0	-----	0	0	0	0	0	0	0	0	23
New Jersey:												
Camden	0	0	-----	0	0	0	0	0	5	0	0	0
Newark	0	0	2	0	3	4	4	0	9	0	0	9
Trenton	0	0	1	0	0	1	1	0	1	0	0	1
Pennsylvania:												
Philadelphia	6	0	1	0	1	4	22	0	36	0	0	12
Pittsburgh	0	0	1	2	86	3	14	0	21	0	4	8
Reading	1	0	-----	0	1	0	1	0	2	0	0	1
EAST NORTH CENTRAL												
Ohio:												
Cincinnati	7	0	-----	1	10	1	4	0	24	0	0	6
Cleveland	0	0	4	0	11	4	11	0	52	0	0	21
Columbus	0	0	-----	0	16	0	2	0	4	0	0	26
Indiana:												
Fort Wayne	0	0	-----	0	0	0	1	0	0	0	0	0
Indianapolis	2	0	-----	1	2	0	2	0	14	0	0	10
South Bend	0	0	-----	0	29	0	0	0	0	0	0	0
Terre Haute	0	0	-----	0	0	0	5	0	0	0	0	0
Illinois:												
Chicago	1	0	3	0	4	5	28	5	50	0	0	43
Springfield	0	0	-----	0	1	0	0	0	4	0	0	0
Michigan:												
Detroit	5	0	-----	2	7	16	19	1	36	0	0	30
Flint	0	0	-----	0	0	0	4	0	0	0	0	0
Grand Rapids	0	0	-----	0	10	1	1	0	7	0	0	0
Wisconsin:												
Kenosha	0	0	-----	0	0	0	0	0	5	0	0	0
Milwaukee	0	0	2	2	2	0	8	0	38	0	0	49
Racine	0	0	1	1	1	0	0	0	6	0	0	2
Superior	0	0	-----	0	96	0	0	0	0	0	0	3
WEST NORTH CENTRAL												
Minnesota:												
Duluth	0	0	-----	0	8	0	1	0	13	0	0	20
Minneapolis	13	0	-----	0	27	5	2	0	16	0	0	2

City reports for week ended November 27, 1943—Continued

	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
WEST NORTH CENTRAL—con.												
Missouri:												
Kansas City	2	0	------	0	0	3	3	0	24	0	0	3
St. Joseph	0	0	------	0	0	0	0	0	4	0	0	0
St. Louis	0	0	148	2	3	3	15	1	6	0	0	8
Nebraska:												
Omaha	3	0	------	0	3	0	1	0	8	0	0	0
Kansas:												
Topeka	0	0	------	0	1	0	2	0	1	0	0	9
Wichita	1	0	1	0	0	0	4	0	3	0	0	0
SOUTH ATLANTIC												
Delaware:												
Wilmington	0	0	------	0	4	1	2	0	0	0	0	0
Maryland:												
Baltimore	8	0	3	0	9	3	9	0	24	0	0	47
Cumberland	0	0	------	0	0	0	0	0	0	0	0	0
Frederick	0	0	------	0	0	0	0	0	0	0	0	0
District of Columbia:												
Washington	6	0	4	0	4	0	5	0	21	0	1	3
Virginia:												
Lynchburg	0	0	------	0	260	0	4	0	0	0	0	12
Richmond	1	0	------	0	6	1	4	0	7	0	1	1
Roanoke	0	0	------	0	0	0	0	0	2	0	0	1
West Virginia:												
Charleston	0	0	------	0	9	0	0	0	1	0	0	0
Wheeling	0	0	------	0	0	1	0	0	0	0	0	6
North Carolina:												
Winston-Salem	1	0	11	0	0	0	0	0	1	0	0	0
South Carolina:												
Charleston	0	0	12	0	3	0	1	0	1	0	0	0
Georgia:												
Atlanta	5	0	11	0	0	0	5	0	4	0	0	0
Brunswick	0	0	------	0	7	1	1	0	0	0	0	0
Savannah	1	0	1	0	0	0	4	0	3	0	0	0
Florida:												
Tampa	0	0	------	0	0	1	2	0	0	0	0	0
EAST SOUTH CENTRAL												
Tennessee:												
Memphis	1	0	31	2	0	0	2	0	4	0	0	2
Nashville	1	0	------	5	0	0	2	0	3	0	0	2
Alabama:												
Birmingham	0	0	------	1	3	0	5	0	1	0	0	0
Mobile	1	0	1	2	0	0	0	0	0	0	0	0
WEST SOUTH CENTRAL												
Arkansas:												
Little Rock	0	0	------	0	0	0	1	0	0	0	0	0
Louisiana:												
New Orleans	7	0	1	0	2	2	10	1	6	0	2	5
Shreveport	0	0	------	0	0	0	5	0	0	0	0	0
Texas:												
Dallas	0	0	------	0	0	0	2	0	1	0	0	9
Galveston	0	0	------	0	0	0	1	0	0	0	0	0
Houston	1	0	------	0	1	0	3	1	5	0	1	0
San Antonio	1	0	------	0	1	0	3	2	0	0	0	0
MOUNTAIN												
Montana:												
Billings	0	0	------	0	2	0	1	0	1	0	0	0
Great Falls	0	0	------	0	37	0	0	0	2	0	0	2
Helena	0	0	------	0	0	0	0	0	1	0	0	0
Missoula	0	0	------	0	0	0	0	0	4	0	0	0
Idaho:												
Boise	0	0	------	0	0	0	0	0	1	0	0	1

City reports for week ended November 27, 1943—Continued

	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
MOUNTAIN—continued												
Colorado:												
Denver	1	0	5	1	7	0	5	0	12	0	0	20
Pueblo	0	0	------	0	64	0	1	0	0	0	0	4
Utah:												
Salt Lake City	0	0	------	0	0	0	0	4	10	0	0	1
PACIFIC												
Washington:												
Seattle	0	0	------	0	3	0	6	0	7	0	0	2
Spokane	0	0	1	1	6	0	4	0	14	0	0	2
California:												
Los Angeles	11	0	4	1	17	5	6	4	25	0	0	5
Sacramento	0	0	------	0	0	0	2	0	3	0	0	0
San Francisco	1	0	1	0	1	3	11	2	17	0	0	8
Total	105	1	253	27	1,044	92	341	26	790	0	13	566
Corresponding week, 1942	85	1	134	27	653	36	407	24	754	2	17	951
Average, 1938–42	111	------	232	[1] 28	[2] 777	------	[1] 363	------	784	4	24	1,160

[1] 3-year average, 1940–42.
[2] 5-year median.

Anthrax.—Cases: Philadelphia, 1.
Dysentery, amebic.—Cases: New York, 1; St. Louis, 1.
Dysentery, bacillary.—Cases: Bridgeport, 1; New York, 7; Detroit, 1; Charleston, S. C., 2; Los Angeles, 8.
Dysentery, unspecified.—Cases: Richmond, 1; San Antonio, 8.
Tularemia.—Cases: Philadelphia, 1.
Typhus fever.—Cases: Charleston, S. C., 1; Savannah, 2; Nashville, 1; Birmingham, 1; Mobile, 2; New Orleans, 4; Dallas, 2; Houston, 1; Los Angeles, 1.

Rates (annual basis) per 100,000 population, by geographic groups, for the 85 cities in the preceding table (estimated population, 1942, 34,253,600)

	Diphtheria case rates	Encephalitis, infectious, case rates	Influenza		Measles case rates	Meningitis, meningococcus, case rates	Pneumonia death rates	Poliomyelitis case rates	Scarlet fever case rates	Smallpox case rates	Typhoid and paratyphoid fever case rates	Whooping cough case rates
			Case rates	Death rates								
New England	9.9	0.0	0.0	2.5	186.3	12.4	54.7	5.0	243.5	0.0	0.0	189
Middle Atlantic	8.9	0.4	3.6	1.8	130.2	13.8	44.2	1.3	87.4	0.0	3.6	56
East North Central	8.8	0.0	5.8	4.1	110.4	15.8	49.6	3.5	140.1	0.0	0.0	111
West North Central	42.1	0.0	330.3	4.4	93.1	24.4	62.1	2.2	166.2	0.0	0.0	93
South Atlantic	38.2	0.0	72.9	0.0	524.1	13.9	64.2	0.0	111.1	0.0	3.5	121
East South Central	17.8	0.0	190.1	59.4	17.8	0.0	53.5	0.0	47.5	0.0	0.0	24
West South Central	26.4	0.0	2.9	0.0	11.7	5.9	73.3	11.7	35.2	0.0	8.8	41
Mountain	8.0	0.0	40.2	8.0	884.3	0.0	56.3	32.2	249.2	0.0	0.0	225
Pacific	21.8	0.0	10.9	3.6	49.0	14.5	52.6	10.9	119.8	0.0	0.0	31
Total	16.0	0.2	38.5	4.1	158.9	14.0	51.9	4.0	120.3	0.0	2.0	86

PLAGUE INFECTION IN KERN COUNTY, CALIF.

Plague infection has been reported proved in a pool of 400 fleas from 22 ground squirrels, *C. beecheyi*, collected November 8, 1943, from a ranch 2 miles northwest of Lebec, Kern County, Calif.

FOREIGN REPORTS

ANGOLA

Notifiable diseases—July–September 1943.—During the months of July, August, and September 1943, certain notifiable diseases were reported in Angola as follows:

Disease	July		August		September	
	Cases	Deaths	Cases	Deaths	Cases	Deaths
Beriberi	27	1	12	2	13	3
Cerebrospinal meningitis	2	1	5	1	1	
Chickenpox			60		127	
Diphtheria			1		4	1
Dysentery (amebic)	140	2	140	8	192	9
Dysentery (bacillary)	2		7			
Gonorrhea	216		196		296	
Grippe, infectious	1,082	25	1,127	15	1,128	19
Hookworm disease	342	4	400	6	448	7
Leprosy	2		9		7	
Measles	626	2	84	1	115	2
Mumps	22		24		19	
Pneumonia	220	33	242	28	252	30
Poliomyelitis	5		1		1	
Rabies			1	1		
Relapsing fever	27		21		20	
Sleeping sickness	246	9	231	28	161	21
Smallpox	24		4		15	
Syphilis	405		446	3	419	1
Tetanus	4	2	6		4	4
Tuberculosis (respiratory)	47	6	32	6	53	7
Typhoid and paratyphoid fever	21		12	1	11	
Whooping cough	223	10	259	4	230	6
Yaws	807		846		1,046	1

CANADA

Provinces—Communicable diseases—Week ended November 13, 1943.—During the week ended November 13, 1943, cases of certain communicable diseases were reported by the Dominion Bureau of Statistics of Canada as follows:

Disease	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Chickenpox		20		206	441	70	91	57	102	987
Diphtheria	1	13	5	45	3	15	1		2	85
Dysentery (amebic)					1					1
Dysentery (bacillary)				8						8
German measles				1	9		2	3	3	18
Influenza		15	15		22				11	63
Measles		3		150	150	29	1	13	11	357
Meningitis, meningococcus				2	1				1	4
Mumps		27		19	116	46		21	51	280
Poliomyelitis	1		1	1			3	2		8
Scarlet fever		24	4	90	100	27	22	13	66	346
Tuberculosis (all forms)		11	3	92	67	11	62	42	19	307
Typhoid and paratyphoid fever				13					10	23
Undulant fever					1				1	2
Whooping cough		8		92	169	13	14	11	16	323

CUBA

Habana—Communicable diseases—4 weeks ended November 13, 1943.—During the 4 weeks ended November 13, 1943, certain communicable diseases were reported in Habana, Cuba, as follows:

Disease	Cases	Deaths	Disease	Cases	Deaths
Diphtheria	33		Tuberculosis	9	3
Malaria	7	1	Typhoid fever	15	2
Measles	8				

Provinces—Notifiable diseases—4 weeks ended November 6, 1943.—During the 4 weeks ended November 6, 1943, cases of certain notifiable diseases were reported in the Provinces of Cuba as follows:

Disease	Pinar del Rio	Habana[1]	Matanzas	Santa Clara	Camaguey	Oriente	Total
Cancer	3	1	3	5		12	24
Chickenpox						12	12
Diphtheria		33	8	1		4	46
Hookworm disease		15					15
Leprosy			1	1		3	5
Malaria	58	10	13	14	6	435	536
Measles		19	3			2	24
Tuberculosis	13	17	12	21		41	104
Typhoid fever	15	26	15	20	3	37	116

[1] Includes the city of Habana.

FINLAND

Notifiable diseases—September 1943.—During the month of September 1943, cases of certain notifiable diseases were reported in Finland as follows:

Disease	Cases	Disease	Cases
Cerebrospinal meningitis	21	Paratyphoid fever	188
Chickenpox	163	Pneumonia (all forms)	651
Conjunctivitis	9	Poliomyelitis	43
Diphtheria	1,439	Puerperal fever	38
Dysentery	15	Rheumatic fever	227
Gastroenteritis	3,644	Scabies	2,293
Gonorrhea	370	Scarlet fever	588
Hepatitis, epidemic	860	Syphilis	298
Influenza	523	Typhoid fever	45
Laryngitis	36	Vincent's angina	18
Malaria	1	Weil's disease	1
Measles	1,240	Whooping cough	525
Mumps	81		

JAMAICA

Notifiable diseases—4 weeks ended November 20, 1943.—During the 4 weeks ended November 20, 1943, cases of certain notifiable diseases were reported in Kingston, Jamaica, and in the island outside of Kingston, as follows:

Disease	Kingston	Other localities	Disease	Kingston	Other localities
Cerebrospinal meningitis		1	Leprosy		8
Chickenpox	1	8	Puerperal fever		1
Diphtheria	4	4	Tuberculosis	19	63
Dysentery	4	2	Typhoid fever	7	65
Erysipelas	1	1	Typhus fever	3	

REPORTS OF CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER, RECEIVED DURING THE CURRENT WEEK

NOTE.—Except in cases of unusual prevalence, only those places are included which had not previously reported any of the above-mentioned diseases, except yellow fever, during the current year. All reports of yellow fever are published currently.

A cumulative table showing the reported prevalence of these diseases for the year to date is published in the PUBLIC HEALTH REPORTS for the last Friday in each month.

(Few reports are available from the invaded countries of Europe and other nations in war zones.)

Plague

Belgian Congo.—Plague has been reported in Belgian Congo as follows: October 25–November 1, 1943, Costermansville Province, 2 fatal cases; Stanleyville Province, 9 cases and 8 deaths.

Egypt—Suez.—During the week ended November 20, 1943, 12 cases of bubonic plague with 4 deaths were reported in Suez, Egypt.

Smallpox

Algeria.—For the period October 11–20, 1943, 51 cases of smallpox were reported in Algeria.

Indochina.—Smallpox has been reported in Indochina as follows: October 21–31, 1943, 76 cases; November 1–10, 1943, 56 cases.

Typhus Fever

Algeria.—For the period October 11–20, 1943, 23 cases of typhus fever were reported in Algeria.

Bulgaria.—For the period October 1–November 10, 1943, 33 cases of typhus fever were reported in Bulgaria.

France—Hautes Pyrenees.—During the month of September 1943, 1 case of typhus fever was reported in Hautes Pyrenees, France.

Hungary.—For the period November 14–20, 1943, 7 cases of typhus fever were reported in Hungary.

Irish Free State—Cork County.—During the week ended November 13, 1943, 1 case of typhus fever was reported in Cork County, Irish Free State.

Rumania.—For the period November 16–23, 1943, 81 cases of typhus fever were reported in Rumania.

Slovakia.—For the week ended November 13, 1943, 31 cases of typhus fever were reported in Slovakia.

Yellow Fever

Colombia.—During the month of October 1943, yellow fever was reported in Colombia as follows: Boyaca Department, 4 deaths; Santander Department, 1 death.

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